MAY 1985 VOL. 3, No. 5 $3.95

FOR IBM PERSONAL COMPUTER USERS

PC TECH JOURNAL

[redacted]

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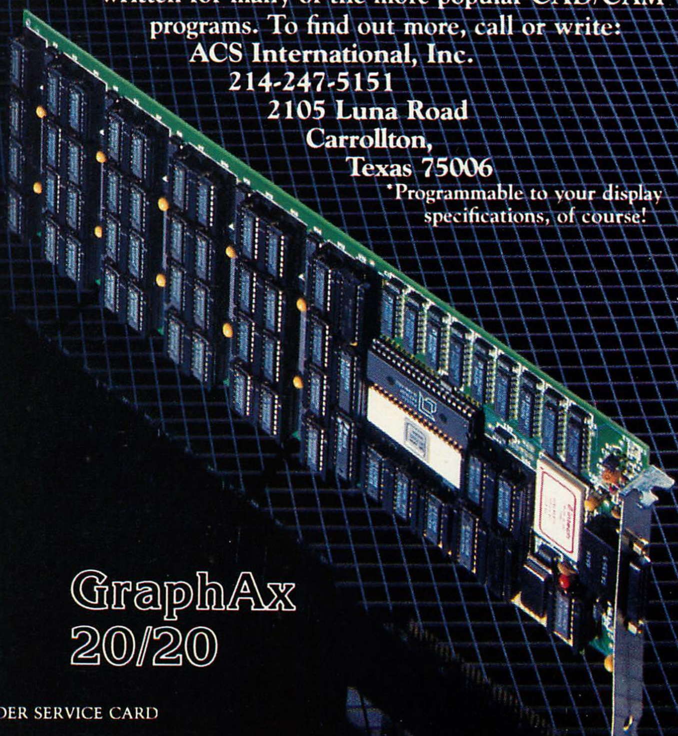

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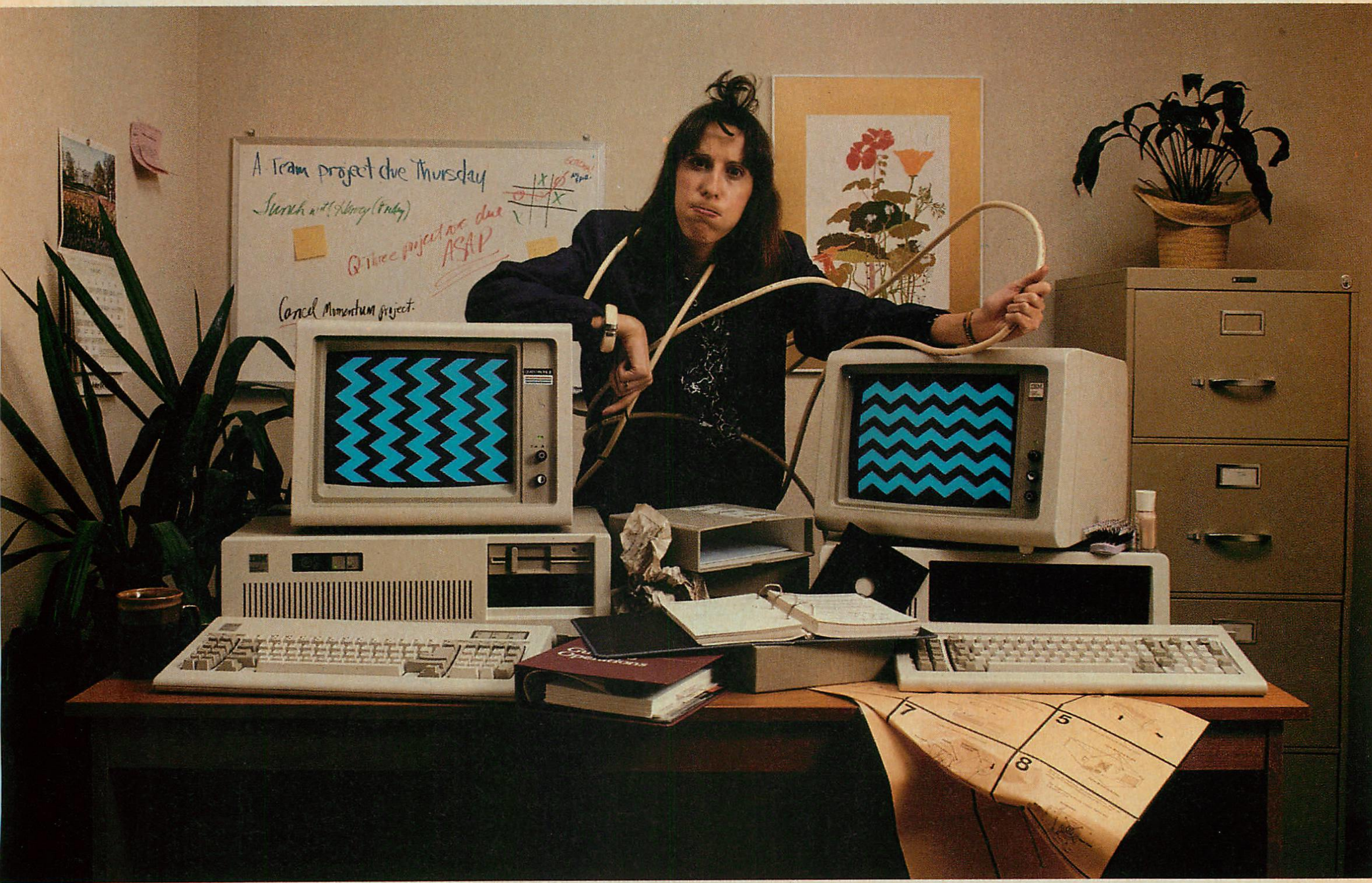

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TECH JOURNAL

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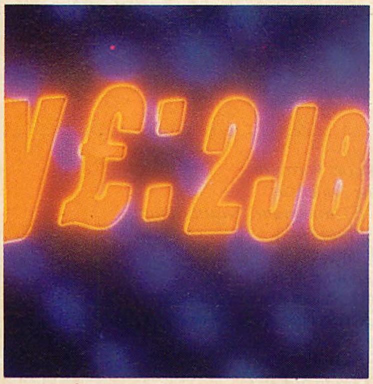

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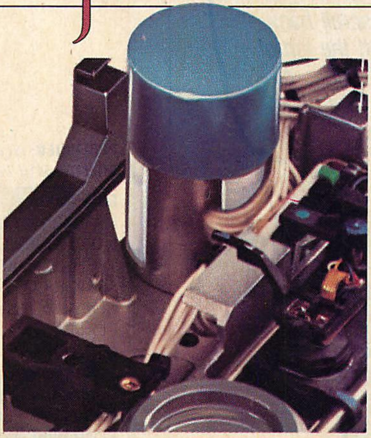

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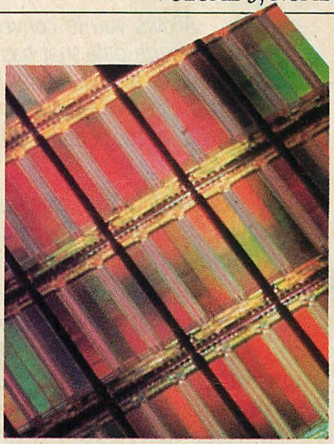

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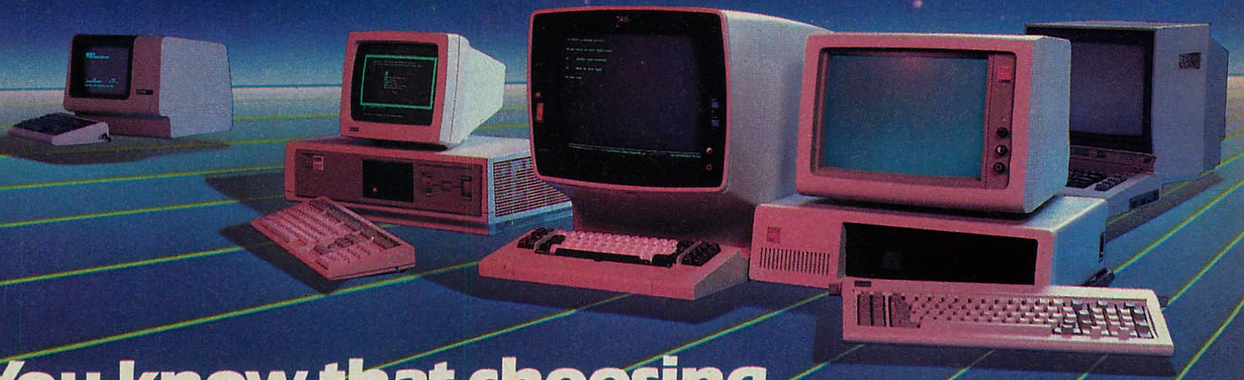

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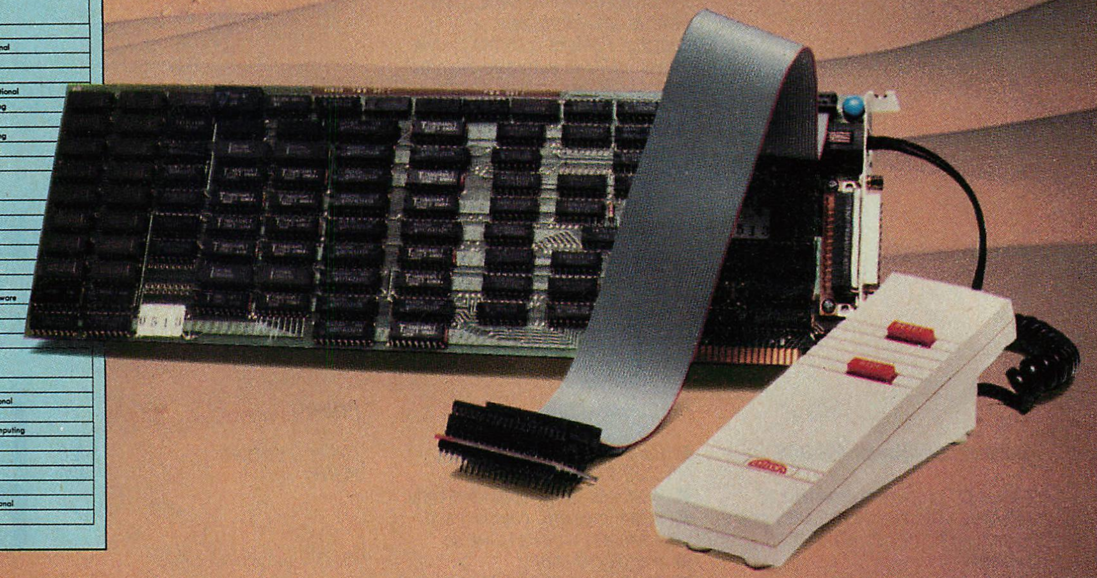
CIRCLE NO. 217 ON READER SERVICE CARD

HOW DO THE TOP-RANKED SOFTWARE FIRMS MAKE THEIR BUCKETS OF SAND SO ROCK SOLID? ASK ATRON, THE PEOPLE WHO INVENTED THEIR DEBUGGING TOOLS.

PC Week/Softsel Top List—December

BUSINESS	
1 1-2-3	Lotus
2 SIDEKICK	Borland International
3 SYMPHONY	Lotus
4 DBASE III	Ashton-Tate
5 MULTIMATE	Multimate International
6 PFS:WRITE	Software Publishing
7 TAX PREPARER 1985	Howardsoft
8 PFS:FILE	Software Publishing
9 WORD PERFECT	Satellite Software
10 MICROSOFT WORD	Microsoft
HARDWARE	
1 SIXPAKPLUS	AST Research
2 HERCULES GRAPHIC CARD	Hercules
3 SMARTMODEM 1200B	Hayes
4 SMARTMODEM 1200	Hayes
5 HERCULES COLOR CARD	Hercules
6 EXPANDED QUADBOARD	Quadram
7 MASTERPIECE	Kensington Microware
8 PC MOUSE	Mouse Systems
9 MODULAR GRAPHICS CARD	Paradise Systems
10 MOUSE	Microsoft
SYSTEMS & UTILITIES	
1 PC MOUSE/PC PAINT BUNDLE	Mouse Systems
2 TURBO PASCAL	Borland International
3 CROSSTALK XVI	Microstuf
4 NORTON UTILITIES	Peter Norton Computing
5 SIDEWAYS	Funk Software
6 PROKEY	Rosesoft
7 PRINTWORKS	SoftStyle
8 SMARTCOM II	Hayes
9 TURBO TOOLBOX	Borland International
10 IN-SEARCH	Menlo Corp.



You can't pick up a PC-related magazine without seeing an editorial reference to Borland International's SIDEKICK™ program. It's one of the most popular programs ever sold to PC and PC-compatible users.

FORTUNE magazine talks about Phillip Khan's brilliantly well-executed marketing plan and a well-designed piece of software. All true. But how successful would Borland be if their product weren't absolutely rock solid?

Someone said that if your only tool is a hammer, you tend to treat all problems as if they were nails. While it's certainly possible to hammer out PC products with mere software debuggers, thousands of professionals in hundreds of companies are using Atron debugging tools.

As you can see, thirteen of the top thirty software packages were created by Atron customers. Their hammer: ATRON'S PC PROBE™, a hardware-assisted software debugging tool that plugs into your PC or compatible.

HOW THE PROS DEBUG THEIR SAND CASTLES

The PC PROBE has an umbilical that replaces your PC processor chip. Now that you can trap and catalog every signal and memory reference, you're ready to pound sand like the big boys do.

PC PROBE can trap a bug which overwrites a memory location. Because complex pointers are normally used for memory addressing, this bug occurs frequently and is quite difficult to find. As for mere software debuggers, what good is a debugger that can be wiped out by a program bug?

What better way to answer the question "How-did-I-get-here?" than to have PROBE display the real-time trace data it saved while your program was executing? Now you can do a grain-by-grain review of any sand storm.

And with the SOURCE PROBE™ upgrade to PC PROBE, you can display source-code statements* as you step through your source program. Through a window, you can continuously view critical high-level data structures. The next several source code statements are also displayed, previewing what the program is about to do.

For screen/keyboard-intensive debugging, PC PROBE's RS232 port allows screen-switching or debugging from an external CRT. For interface/hardware debugging, PC PROBE can act as a logic analyzer, trapping interrupts, I/O locations, and even signals brought in from external logic probes. All this is impossible to do with software debuggers. Which is why the pros use PC PROBE.

TODAY THE DESERT, TOMORROW THE WORLD?

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*PC PROBE is compatible with Microsoft C, Lattice C, C Innovations C, Microsoft Pascal, and Assembly language. SOURCE FOR CHART: PC WEEK/SOFTSEL TOP LIST, PC WEEK, 1/29/85. Multibus™/INTEL™ Intel Corp., SIDEKICK™ Borland Interntional, PC PROBE™/MBUS PROBE™ Atron Corp. Atron also has a Multibus™ debugging product for your integrated 8086/8087/8088 applications, and the user interface is identical to PC PROBE's. Advertising by The Rick Bennett Agency, 408/258-2708.

CIRCLE NO. 203 ON READER SERVICE CARD

Mainframe Strategy

IBM's recent Series/1 announcement provides some insight into future IBM strategies.

In the March and April issues of *PC Tech Journal*, I used this space to ruminate about operating environments and speculate on the future. In March I spoke of TopView and IBM. In April it was Microsoft, XENIX, MS-DOS, and Windows. This month, I was surprised by an IBM announcement that has not changed my thoughts from those previous editorials, but it has made me think about a grander IBM strategy.

The announcement was not unexpected, but the content was different than what had been anticipated. The rumor mill had been grinding one way, and IBM went in a slightly oblique direction. I was expecting IBM to announce a tiny System/36 based on a PC/AT. Instead, it announced a tiny Series/1 based on an AT (or an XT).

The System/36 product, when it comes, will be a significant one for IBM. There are almost 100,000 System/36s installed today. More important, however, is the thriving third-party software industry that the System/36 has spawned in dozens of vertical markets. IBM itself has a catalog full of applications. These vertical markets are very important to future sales of computer systems, so IBM can best serve its own interests by lowering the entry price of a family of processors. The /36, which has a good reputation for usability and user-friendliness (one IBM reseller says 80 percent of his System/36 installations are operated by the users), is IBM's best and most important multiuser system and is the smallest, reasonable IBM business computer after the PC family. It is a natural for a low-end model.

An AT/36 (my coinage) is predicted to have a mid-teens entry price, run a native copy of the System/36 operating system (SSP), and support four ASCII terminals. Rumors say the AT/36 will be 100-percent compatible. The claim about its terminal is quite interesting. System/36s usually use special System/36-specific terminals, but IBM has apparently built a controller board that performs a 5251 emulation for dumb ASCII terminals. That means a user can buy Qume's new $395 terminal, an IBM 3101, or even a regular PC running a terminal emulation program. What this really does is keep the terminal price low and lets IBM sell the system without excess baggage. IBM could also sell the small AT/36 into business offices that already own some PCs.

The AT/36 strikes me as quite an interesting product for IBM. It has a sales force ready to go—one that will understand the product before it leaves the starting gate. A ton of serious applications already exist; with little or no conversion, these applications will be quickly available. Best of all, IBM will be able to point directly at a future growth path for the entry-level customer. When the baby runs out of steam, the System/36 configurations can run the same software and operate in just the same way as the little version did. Buy an AT/36, and you will become an official, true-blue, IBM customer. And after that . . . *mainframes.*

SERIES/1

So much for priorities. I believed the rumors, got excited about the great sales story above, and IBM came along with, not a small System/36, but the *Series/1* in an AT or XT. IBM tried to become a player in the minicomputer market with the Series/1. If the PC had been marketed with the same caution and conservatism as the Series/1, we would all be using Rainbows today.

The Series/1 Processor is a dog. Any Data General or Digital Equipment Corporation mini (especially DG) at half the price can run circles around the Series/1. If you are looking for performance, don't turn to IBM for a mini.

Now to be fair, IBM has a strategy for the Series/1 that keeps it selling. First, IBM has developed extensive manufacturing software for the machine, and it sells many manufacturing systems to a very large and important computer manufacturer: itself. Second, it has developed extensive communications hardware and software for the Series/1 and often quotes such systems as communications front-ends or concentrators for the larger mainframes, especially in transaction processing situations. This is, in fact, reasonable. Although the machine is slow, it can be expanded almost indefinitely with more expansion chassis than can be imagined. Each of those chassis can be loaded to the gills with communications boards. The machine is also incredibly reliable—a strong selling point for the communications market. Predictably, IBM has a realtime operating system kernel called Event Driven Executive (EDX) on its price list, making the Series/1 the only IBM computer to be so equipped.

My words imply that IBM has really goofed with this one. The technical assessment will have to wait for awhile, but I see an interesting strategy brewing, as well as some clues about IBM's potential to do a few magic tricks.

Let's begin with the announcement. There are two new computers, the 5170 model 495 and the 4950. No, that is not a misprint. The 495 is the AT (catch the 5170 clue?) with a Series/1 card set, and the 4950 is a *modified* XT with the set. The systems are available only as "factory-shipped units," meaning that upgrades to existing machines are impossible. Either system allows attachment of up to four "IBM 3101 display stations or their equivalent," as the IBM press release puts it. As with my imaginary AT/36, just about any ASCII terminal will probably work. The XT model comes with or without a fixed disk (it did say *modified* XT, after all).

Software announcements include Series/1 IX (UNIX System V) for the largest Series/1 (model 4956), the Transaction Processing System for medium and large Series/1s, and new ver-

sions of EDX (5) and Realtime Programming System (7 and 7.1) for the new desktop versions.

Finally, a 400KB-per-second link between the IBM PC-Network and the standard Series/1 processors (4954, 4955, and 4956) provides a gateway from a network of PCs to another PC network, a Series/1, or upward through the Series/1 to a mainframe. The connection requires a pair of channel attachment cards, cable, and software.

So what do we have? As in the AT/36 strategy I outlined above, we have a lower entry price for the Series/1 family. Furthermore, the announcement is clearly oriented toward communications, the area of the Series/1's greatest market strength. Improvements in the software for multiuser (Series/1 IX), software development (IX again), and transaction processing clarify the niche IBM seeks for the family.

On another front, IBM now has an offering that can provide file service for networks, or simply data distribution from mainframes to lots of PCs. In fact, the offering seems to support the notion of distributed processing, if anyone really knows what that means. I see a sensational sales story for all of IBM here. Now the corporate customer, IBM's bread and butter, can attach PCs to anything from anywhere using nothing but IBM equipment, but avoiding the aging 3270 communications gear and its limitations. In the meantime, the employee in accounting in Akron still can have a PC or AT or whatever on his/her desk. Better yet, perhaps that accountant can dump the 3270 and find the desktop again. After that, who knows? Maybe more *mainframe* sales to support all those PC-networks?

MAGIC TRICKS

After I finished analyzing the market position for these two new machines, I started thinking about two technical details that might be of importance to IBM in the long term.

First: IBM has built a chip-level processor in-house (as near as I can tell) for the new desktop Series/1s. It has thus made a radical departure from its normal behavior of buying processor chips outside. Even in the case of the XT/370 or AT/370, the processors were microcoded Motorola 68000 chips. IBM seems to be letting the world know it can build its own chips if it has to.

Frankly, I'm sure it can. The company might be very inclined to build its own when the instruction set involved is one of its proprietary ones. Whether IBM can produce processor chips in volume is another question. It seems to be following the long lead of other mini manufacturers by migrating its popular instruction sets downward into smaller configurations. Both DEC and DG have already done so and are almost certainly working on miniaturizing their biggest machines. The ability of a computer manufacturer to produce a micro version of its middle processors is important for the long haul.

Second: IBM chose not to announce just a smaller version of the Series/1. Instead, it built the machine *inside* a standard PC. Sliding a secondary processor onto the bus of a PC is not a great trick, but it is important that IBM is doing so. The next step in making this trick really spectacular is learning how to build a basic system board without a personality and then adding whatever is desired. Put in a PC card, a couple of Series/1s, and a System/36 or System/370. Mix and match. Go wild. Picture an AT on a desktop in a computer room somewhere performing as two or three Series/1s and controlling communications for a particular application. Visualize a room full of equipment squished down to one tabletop in a small business. Imagine.

This *is* important. IBM is learning something (a lot) about building multiprocessor systems in which the processors are loosely coupled in hardware and tightly coupled in software. It will not be long before add-in processors are being handled by a PC with the ease it currently handles new driver software in an on-board ROM (for example, the fixed-disk BIOS). If there was an add-in card with a 286 coprocessor and 512KB of memory, just think of the power that would come out of a box the size of an AT with two or three more processors installed.

Let me put my feet on the ground again and get serious. There is an important message lurking in the Series/1 announcement. I've scattered clues to it above: mainframes.

IBM is in business to sell its larger computers to larger businesses. Today's small businesses are tomorrow's large businesses. Therefore, IBM needs to be sure that today's small business buys IBM and stays with IBM. To get the word out, it has been selling a very popular little box with its name on it for the past three years or so. Question: how will all the people who bought that little box start thinking mainframe? The Series/1 announcement provides the answer. They will buy their PCs, hook them together with PC-Network, and then move *mainframeward* with Series/1 communications.

Look up. There's an IBM mainframe in your future.

GETTING ANSWERS

Nothing is more gratifying to the editors of this magazine than reader response—both written and verbal. We read your letters avidly and deal with them in our letters department.

It's the phone calls that worry us. You call with exciting ideas, subscription queries, the need for more information about the material we publish, and questions about PC applications. They are engaging calls, but if we engaged in all of them we would not get the magazine out.

The calls fall into two categories: questions we cannot answer over the phone because it is necessary to have a written query to respond, and questions that we cannot answer because we don't have the information.

There are ways to get answers. Here are five of the most frequently asked questions from our readers and how to get answers to them:

Q. I would like to talk to one of your editors about writing an article.
A. All queries must be sent to us in writing. They are passed around the office for each editor to consider.

Q. I subscribed in February but have not yet received an issue.
A. Direct all subscription inquiries to 1-800/525-0643.

Q. I remember seeing a patch to a bug in DOS. Did it appear in one of your articles?
A. We do not have the resources to help figure out the article to which you are referring. Check a standard abstracting publication for the PC; for example, *Editorial Abstracts* or *The IBM PC Index*.

Q. I started subscribing last year. Now I want to get all issues of *PC Tech Journal* from the beginning. Can you send them to me?
A. Call 1-303/447-9330 for back issues.

Q. How do I use *XYZ* application on my PC?
A. Consult other PC users via electronic mail or write *PC* magazine's "User to User" column.

—*MS*

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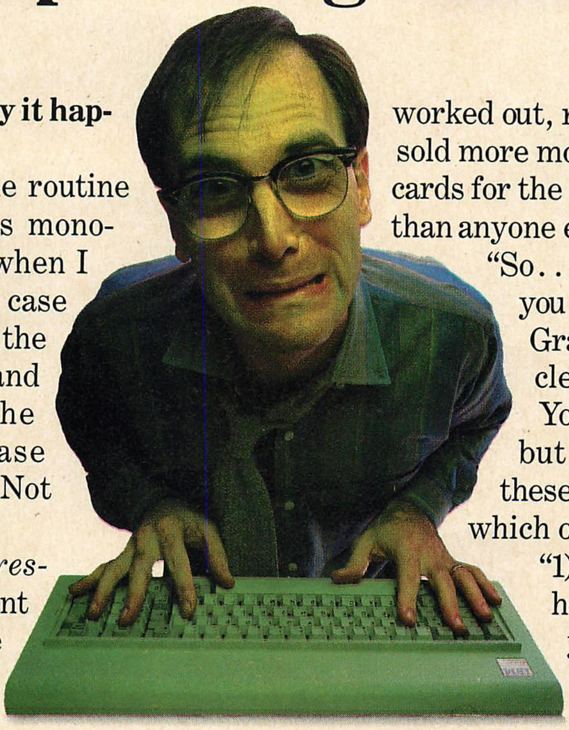

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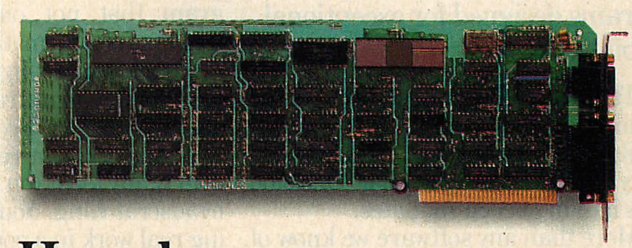

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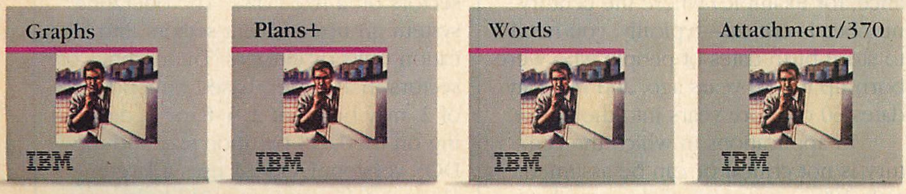

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MORE MAVERICKS

Thank you very much for your positive review of the Maverick SMD PC-80 hard-disk controller ("The Maverick Controller," Julie Anderson, January 1985, p. 58). However, we would like to point out that, in addition to marketing the Maverick controller, Interphase also markets the FDS 590 and the RDS 300 series of hard-disk subsystems, which use the Maverick controller.

RDS subsystems come with 50 or 75MB; each includes a 25MB removable hard-disk cartridge. The RDS 590 offers 590MB of fixed-disk storage.

All subsystems provide average access times of 20 to 30 milliseconds and performance that is three to four times that of most 5¼-inch Winchesters.

A. Edward Turner
Interphase Corp.
Dallas, TX

PACKING UP

In your January 1985 issue, I came across a very informative article, "PACKing the Date and Time" (Patrick Finan, p. 46). It brought to mind a long-running question: how does one interpret the "TIMESTAMP" produced on an IBM 4341 mainframe?

Also, I tried the Pascal programs at the end of the article and could not get them to work using Turbo Pascal.

James Kostran
West Seneca, NY

The TIMESTAMP on data produced by an IBM 4341 system probably uses a similar, but not identical, packing format. Unfortunately, it is more a function of the operating system than the hardware, and I cannot be of any help without additional details and an example of the packed TIMESTAMP.

The key to using the routines for packing the date and time is that they are transformed into a 16-bit data type. In IBM Pascal, such a type is called a word. *Unfortunately, Turbo Pascal and IBM BASIC have only one 16-bit data type called* integer, *but the high order bit indicates sign of the number. Thus, integer types provide only 15 usable bits, which is not enough to pack the date and time values into the DOS format.*

Turbo Pascal users might simulate an unsigned 16-bit quantity by using two data fields of type byte. *I have not tried it, but it should not be too difficult using the techniques I described.*

—Patrick Finan

I wrote to you recently, implying that your magazine was perhaps less than a programmer's dream and more directed to dBASE and word processing shufflers. I was wrong. Since November the articles have contained a great deal of usable information. Patrick Finan's "PACKing the Date and Time" (January 1985, p. 46) inspired me to a solution to a problem I didn't realize I had.

I had to read Mr. Finan's algorithm through several times before I figured out why I couldn't store a date in BASIC integer form. (This was apart from the unbelievable number of typos.) The problem is that BASIC allows you only 15 bits for the value, using the 0 bit for the sign. The solution is to subtract 2^15 (32,768) from the value before storing it and to add the same amount when retrieving it.

Mr. Finan's method allows a range of about 127 years to be stored in two bytes. From my own experience, this is not enough for applications (life insurance, for example) where the century number is critical—typically, you need to store birth dates of people who were born up to 100 years ago, and maturity dates 60 or more years into the future.

In applications in which the century is not critical or can be assumed, only 100 years worth of days needs to be store. Furthermore, typing in 19xx instead of xx gets old quickly if you are operating a CRT all day.

An algorithm I developed rapidly converts an input date in three strings (month, day, and year) into a standard Microsoft BASIC disk storage MKI$ string. An advantage to this method is that no valid date creates a stored value equal to either 0 or spaces; fields with no value need no special treatment.

The program listing for my algorithm is available to readers sending a stamped, self-addressed envelope to 2101 Albert Road, Carrollton, TX 75007.

David deJongh
Carrollton, TX

FIXED-DISK PERFORMANCE

I greatly enjoyed the articles on internal fixed-disk systems for the PC in the November 1984 issue ("Ten by Ten," Thomas V. Hoffmann, p. 52; "Fixed-Disk Benchmarks," William J. Hunt, p. 64). Mr. Hoffmann gave the most comprehensive hands-on overview of the expanding, add-on fixed-disk market available. It enabled me to make accurate buying suggestions to friends. Mr. Hunt's benchmark programs for these fixed disks were fascinating. I tried to purchase his software from *PC Tech Journal*'s Listing Diskette Service but was told the service had been discontinued. Can you tell how to obtain Hunt's programs?

I installed several 30MB Maynard Quantum fixed disks and learned of another factor in disk performance: cluster size. Microcomputers find it more convenient to manage smaller units of storage than the tens of thousands of sectors on a fixed disk. The operating system groups adjacent sectors into allocation units or clusters. The number of sectors in a cluster, based on a power of 2, may be set at 2, 4, 8, or 1, depending on the DOS partition size and the DOS version. DOS 2.1 uses a larger cluster of 16 sectors (at 512 bytes per sector, each cluster contains 8,192 bytes) than does DOS 3.0's four sectors (at 512 bytes per sector, each cluster

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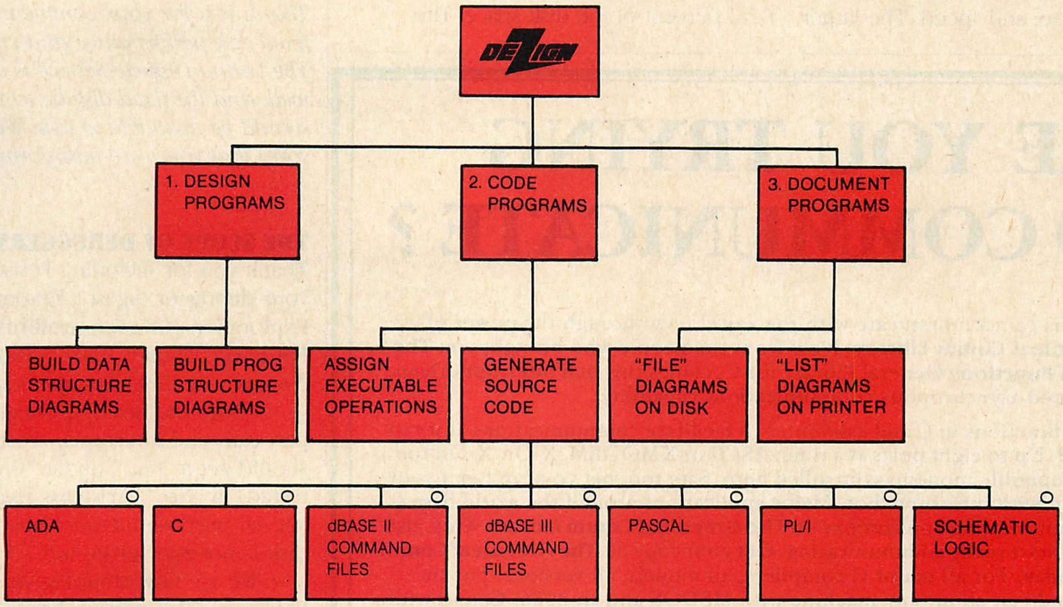

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- DEZIGN-PC runs under DOS 2.0 and 2.1.
- DEZIGN-86 runs under CP/M-86 1.1 and Concurrent CP/M-86.
- DEZIGN-16 runs under ZDOS on Zenith Z-100 computers.

"Principles of Program Design," by M. Jackson, Academic Press, describes the JSP methodology and is available directly from Zeducomp and from most professional/technical book stores.

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contains 2,048 bytes) for the 30MB drive. On a 30MB disk, DOS 2.1 allocates 4,074 clusters; DOS 3.0 creates 16,279 clusters.

I find that my PC has to work 1.5 to 4 times longer doing sequential reads on this much larger number of clusters under DOS 3.0 as a result. Using the new 3.0 Norton Utility Timemark program and the technical readout from NORTON.COM, I studied the effects of the two types of DOS on storage, cluster size, and speed. The larger the cluster, the faster the performance, but if the file size is small, the greater the slack or empty space in each cluster. If I format the 30MB Maynard in DOS 3.0 with its 2KB cluster size, 9.6MB of files take up 30 percent of the fixed disk's space. Loading my WordPerfect word processor takes 10 seconds. If I then reformat the same disk with DOS 2.1, with its 4KB clusters, word processor load time drops to 4 seconds. The files now occupy 13.5MB on the disk, or 42 percent of the disk space. The CHKDSK utility is similarly affected: reading the 30MB takes 8 seconds under DOS 2.1, and 12 seconds under DOS 3.0. Setting the number of buffers higher helps, but does not remove differences between the two versions.

One has a trade-off between the efficiency of PC storage on a large fixed disk and the sequential read speed.

Laurence Greenhill
Mamaroneck, NY

Thank you for your comments on fixed-disk performance and cluster size. The Listing Diskette Service is alive and well, and the fixed-disk benchmarks should be available to you. We are very sorry that you were misinformed.

—WF

THE SCOPE OF DEBUGGERS

Thank you for including Periscope in your debugger digest ("Entomological Explorations," Steven Armbrust and Ted Forgeron, January 1985, p. 88). The accompanying table has two bugs.

Under the heading "Single-step past calls and interrupts," Periscope should get a "Yes;" under "Copy-protected," a "No." Periscope requires the special purpose memory board, but the disk is not copy-protected.

We are now shipping version 1.1 of Periscope. This version has many new features, such as user-controlled windows for data, register, stack, and/or disassembly information; support of Phoenix's Plink and Digital Research's LINK86 for program symbols; PC/AT support and real-mode 80286 opcodes; the ability to debug device drivers, non-DOS programs, and memory-resident programs; and system crash recovery.

Brett Salter
Data Base Decisions
Atlanta, GA

Most of the debuggers reviewed use an option on their TRACE or STEP commands to single-step past calls and interrupts. Periscope includes this feature, but implements it with a different command (JUMP), which we missed. Regarding copy protection, Periscope is protected in one sense. Although users can make as many copies as they please and can even install it onto a hard disk, the software runs only when the Periscope board is installed. This limits its use to a single machine.

—Steven Armbrust

A review of Periscope is scheduled for a future issue of PC Tech Journal.

—WF

SUPERCALC FOR THE 8087

"The Limited Joys of Translated Software" (James Creane, January 1985, p. 142) states that Microsoft's macro assembler could produce a version of the Sorcim/IUS spreadsheet, SuperCalc 3, that could use the 8087. In fact, such a version already exists. SuperCalc 3, release 2, supports both the 8087 and the 80287.

Leanna Gaskins
Sorcim/IUS Micro Software
San Jose, CA

USEFUL WORK

Just a note to tell you how much I enjoyed the February 1985 issue of *PC Tech Journal*. I really enjoyed the directory program by Ted Mirecki ("Dipping into Directories," p. 67), and found almost all of the other articles useful. Please continue to have a lot of useful programs and routines rather than a bunch of reviews. You continue to look better. Keep up the good work.

Jeff Jacobsen
Logan, UT

PASCAL PROBLEMS

The Turbo Pascal article by Michael Covington ("The Power of Turbo Pascal," February 1985, p. 112) was much appreciated. There was a minor but disabling error in the diskspace procedure that was included; the bx register should be used to determine free space, not the dx register. The latter returns the *total* amount of space on the disk, used and not used.

It would be helpful if someone with good knowledge of the different Pascal implementations in use could provide some general guidelines, with examples, of how programs from one Pascal could be translated into others. The article by Robert Stam (Environmental Excavations," February 1985, p. 90) would be a good example. In addition, Turbo permits in-line incorporation of machine language code; an article that describes the interfacing of short machine language routines to various different Pascals would extend the usefulness of various technical articles that have appeared in publications, including *PC Tech Journal*.

Jerome Blumenthal, M.D.
Binghamton, NY

Dr. Blumenthal is exactly right about this. The correct register should be bx. I apologize for the error.

—Michael Covington

CUT WORDS

Every documentation writer should read the sidebar, "Writing Improved While You Watch," to the article, "Documentation That Works" (Michael Covington, January 1985, p. 165). Mr. Covington is right: good writers cut every unnecessary word. But Mr. Covington quit when he was just getting started.

"One of the best ways to improve your writing is to cut out unnecessary words" may be 40 percent off the original, but it has a long way to go. Why equivocate? Never say "One of the best ways . . ." when you can make the statement positive: "The best way . . ." That engages your reader. It also cuts two unnecessary words.

Putting the action first adds punch. "Cutting out unnecessary words is the best way to improve your writing." (One more unnecessary word is gone.)

What help is "out" or "your?" "Cutting unnecessary words is the best way to improve writing." (Ten words left.)

Now I am warming up. Replace "the best way to improve" with the active verb "improves." And our reader is not stupid—"unnecessary" is unneces-

sary. "Cutting words improves writing." Imperatives can save even more words. Commands work! "Cut words!"

You could go too far, too. Still, Mr. Covington's point is worth making again. Good writers cut every unnecessary word.

Martin L. Rinehart
New York, NY

DOS REDIRECTION BUG

I recently attempted to use the redirection of standard output under PC-DOS 2.0 to append text to a text file. The results were peculiar, to say the least. According to the IBM manual,' >> filename' causes 'filename' to be opened (created if necessary) and positions the write pointer at the end of the file so that all output is appended to the file. After much consternation over my failure to append to a file, I uncovered a bug in the redirection code.

The problem centers around marking the end of a file (EOF), and the subsequent locating of that mark. DOS uses ^Z (1Ah) to mark EOF, and the first Z found in a file ends the file as far as text is concerned, although the file has the remaining bytes of the cluster (1,024 bytes DSDD) available.

By scanning the hex content of files that had been appended to by redirection, I found that the appended data were indeed there, which was indicated by the increase in the DOS reported file size, but it followed rather than preceded the existing EOF (1Ah) mark. For all practical purposes the text was hidden, though I could recover it by modifying the sector to remove the offending EOF mark.

I see no good way around this bug short of a patch from IBM. I also do not know if it exists in DOS 2.1 or 3.0. I would be interested in your reaction.

Kevin J. O'Connor
Center Valley, PA

This is indeed the case, all the way through DOS 3.0. Additionally, DOS fails to mark the end of the appended text with a new ^Z, which might cause "unexpected EOF" errors when reading the file with a processor that expects to see ^Z at EOF. To patch a file to which standard output has been appended, you must both remove the ^Z at the end of the original file and add ^Z to the end of actual text. This is plainly a bug in DOS, and if any reader has traced the problem and worked out a patch, PC Tech Journal *would like to print it as a Tech Notebook.*

—JD

CODE VIA PHONE

I would like to second the suggestion made by Doug Sharp in his letter published in the December 1984 issue ("Listing by Telephone," p. 32). It would be very nice to be able to obtain source code via a phone call.

Robert E. Kribel
Auburn, AL

ERRATUM

The article "Irresistible DOS 3.0" (Julie Anderson, December 1984, p. 74) incorrectly stated that once the read-only attribute is set on a file, an attempt to COPY the file would return the message "File creation error" from DOS. In fact, an attempt to COPY to the file or otherwise overwrite it returns the error message. This is not a method for copy protection as some of our readers had hoped after reading the article. We regret the misinformation.

—JA

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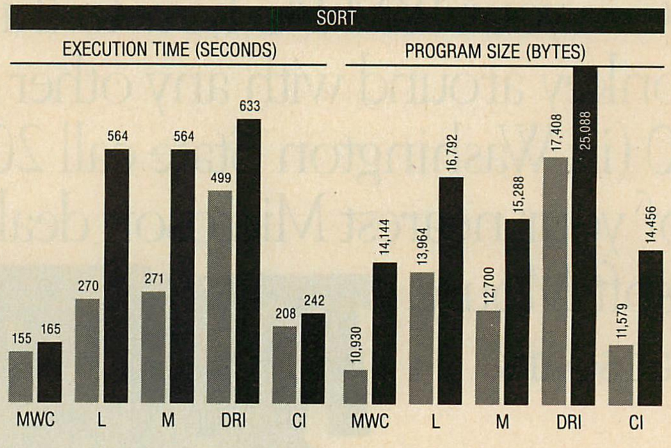

■–Small Memory Model
■–Large Memory Model

NOTE: Sort program as in Byte, August 1983, p. 91. Register declaration added. Further information on these benchmarks available from Mark Williams Company upon request.

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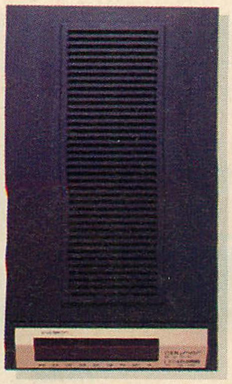

Courier 2400

U. S. Robotics' 2400-baud modem doubles throughput and enhances the Hayes standard at a terrific price.

In computing, particularly in business computing, nothing is ever done quite fast enough. Therefore, of all the ways a modem standard may be enhanced, speed remains perhaps the most important. In recent months, at least ten modem manufacturers have *announced* products that, by operating at 2400 baud (240 characters per second), effectively double the throughput of the ubiquitous 1200-baud asynchronous communications link.

However, as of this writing, only U. S. Robotics is actually delivering such a product—the Courier 2400—and at the extremely aggressive list price of $699. Evidently, pushing 240 characters per second through the low bandwidth channel represented by a telephone line (and doing it for less than $1,000) is not as easy as modem manufacturers had assumed. In consideration of the technological and pricing breakthrough represented by this product, *PC Tech Journal* has chosen the U. S. Robotics Courier 2400 modem as its May 1985 product of the month.

Since D. C. Hayes set the standard with its original 300-baud modem in late 1981, the field has been left wide open for other vendors to add competitive value to their modem products by implementing the Hayes standard of functionality and then building upon it. Among 1200-baud modems, the Prentice PopCom and Prometheus ProModem 1200 are perhaps the most innovative products to do just that.

With the Courier 2400, speed is the revolutionary aspect; it may take a little time for the rest of the telecommunications industry to make use of it. None of the major information services used by the public currently supports 2400-baud communications.

The Courier 2400 and its later siblings will find their first use in point-to-point links now served on both ends by Hayes or Hayes-compatible modems. Many of these links span the continent; some span oceans. Across such distances, connect time is money. On a transcontinental link that may bill hundreds of dollars a month, changing to 2400-baud modems can pay back the incremental cost of the modems over 1200-baud technology (about $200 per modem) in a matter of *days.*

The Courier 2400 represents other evolutionary improvements to the Hayes standard. Built into the Courier's ROM code are two help screens: one details all commands available from command mode; one explains the 16 programmable registers. The user types AT! to view the command help screen, transmitted to the screen from the modem; typing ATS! displays the register help screen. (How often have you scrambled for the manual to look up which register sets the number of rings before autoanswer?)

PRODUCT NAME
Courier 2400

COMPANY
U. S. Robotics, Inc.

ADDRESS
1123 West Washington Blvd.
Chicago, IL 60607

TELEPHONE
312/733-0497

PRICE
$699

A much-lamented deficiency in the Hayes standard is its inability to distinguish among a dead line, a dial tone, a busy signal, or the voice of the liquor store owner whose phone number is one digit removed from MCIMail's dial-up. Like some other innovative modems (PopCom, for example), the Courier 2400 returns a distinct result code upon encountering each of these signals.

Then there are the switches. Many modems must be opened physically to change switch settings, usually by prying against plastic parts with a screwdriver, risking broken plastic and skinned knuckles. The Courier 2400 provides unencumbered access to the switches through a well in the bottom plate of the modem. Furthermore, the meaning of each switch is clearly printed on the bottom plate, along with a summary of all registers, all commands, and all LED indicators.

The Courier 2400 also has one switch that the Hayes modems do not have: the *quad* switch reverses the meaning of RS232C pins 2 and 3. Whether the Courier will be connected to DTE (data terminal equipment) or DCE (data communications equipment), the user may do so without having to resort to a "nullmodem" or "modem eliminator" cable.

The Courier 2400's volume control is a slide pot on the side, easily adjustable with one finger. The modem back plate includes a modular telephone jack for both the wall connection *and* a desk phone, saving the cost and bother of a "Y" plug for the modular outlet.

We have successfully used the Courier 2400 with Crosstalk XVI, ASCOM, Kermit, PC Talk, and several home-brew terminal programs.

The Courier 2400 resides in a pebble-finish plastic case that is certainly rugged enough, yet somehow seems a bit of a letdown. We are all very used to the wraparound aluminum extrusion in which the Hayes modem nestles, impervious to all mayhem. (It can truthfully be said that you can dance on a D. C. Hayes modem.)

You *cannot* dance on the Courier 2400. You can, however, use it to double the throughput of your communications links, at relatively little additional cost over a Hayes 1200-baud modem. That is certainly an acceptable trade-off. The Courier 2400 is a winner.

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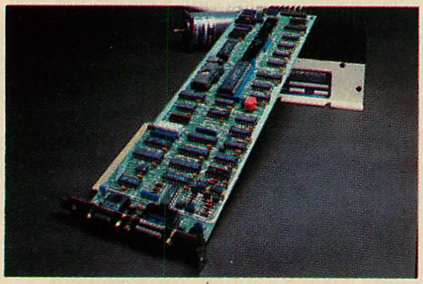
Compumotor Corporation, 1179 N. McDowell Blvd., Petaluma, CA 94952; 800/358-9068; in California, 707/778-1244 (collect)
CIRCLE 490 ON READER SERVICE CARD



Compumotor's PC21 Indexer

The **51C259** is a CHMOS static-column, 64K-by-4 dynamic random-access memory (DRAM) from **Intel Corporation**. It is the latest in a line of 256K dynamic RAMS. The 51C259 will be offered in two versions: the 51C259H, which takes advantage of the high-bandwidth benefits of CHMOS, and the 51C259L, which emphasizes the low-power requirements. The CMOS 256K DRAMs are especially in demand for low-power uses, such as portable computers, and high-bandwidth memory applications, such as graphics and digital signal processing. For quantities of 1,000 or more, prices range from $28.75 to $48.65 each, depending on performance characteristics; expected price for the 51C259H-20 is $18 each for 10,000 (available in the fourth quarter of 1985).
Intel Corporation, 5200 NE Elam Young Parkway, Hillsboro, OR 97123; 503/681-4203
CIRCLE 488 ON READER SERVICE CARD

Pragmatic Test Systems has introduced the **PTS-1000** series of PC-based integrated circuit testers. The four initial members of the family are the PTS-1000/1005 digital test systems and the PTS-1010/1015 linear/digital test systems. The PTS-1000/1010 are controlled by the PC/AT; the PTS-1005/1015 are controlled by the PC/XT. The test systems can be used for manual device handling or they can be interfaced to automatic handling equipment, making them suitable for use in incoming inspection, production test, and laboratory applications. Prices: PTS-1000, $35,950; PTS-1005, $27,950; PTS-1010, $49,950; PTS-1015, $42,950.
Pragmatic Test Systems, Inc., 1405 S. Milpitas Blvd., Milpitas, CA 95035; 408/943-1920
CIRCLE 491 ON READER SERVICE CARD

Extended Systems has announced its **LaserConnection Family**. The family is designed to unleash the power of the Hewlett-Packard LaserJet printer. Users who previously could not interface the LaserJet to their systems or applications may now enjoy full-feature support. Extended Systems has introduced the first four members of the family: **ESI-2646** allows the LaserJet printer to be interfaced to the IBM Displaywriter System without user retraining or sacrificing the power of the text processor. **ESI-1312** allows the printer to work with the IBM DisplayWrite 2 software family. **ESI-2613** allows the LaserJet printer to be automatically shared by up to three PCs equipped with parallel printer ports; **ESI-2617** allows the LaserJet to be automatically shared by up to three PCs with serial output ports. Both the ESI-2613 and ESI-2617 include ESI-1312. Prices: ESI-2646, $1,995; ESI-1312, $895 (licensed on a site basis); ESI-2613 and ESI-2617, $1,695 each for the initial installation at a site, duplicates for the same site are $895.
Extended Systems, 6062 Morris Hill Lane, P.O. Box 4937, Boise, ID 83711; 208/322-7163
CIRCLE 480 ON READER SERVICE CARD

Advanced Digital Information Company has announced a 67MB file-addressable, high-performance cartridge tape system for a wide variety of applications and computer interfaces. Important features of the **500 series** tape drives include: 67MB preformatted file-addressable tape cartridge; random-access file addressability; guaranteed cartridge interchange from system to system and cartridge to cartridge; automatic error detection/correction with guaranteed error rates of less than one in 10^{10} bits; internal tape certification and verification; microprocessor-controlled single-track head for automatic mechanical and electrical adjustment; no required field maintenance (all mechanical and electrical adjustments have been eliminated); internal diagnostic capability for drive, controller, cartridge, and interface; and turnkey responsibility. ADIC guarantees the total system including interface, drive, cartridge, and software. The system features international power supply and approvals. The series will operate on any AC line voltage from 100 to 240 volts and 47 to 60Hz. Prices from $2,900 to $3,900.
Advanced Digital Information Company, 723 9th Avenue, Building A, Kirkland, WA 98033; 206/822-5579
CIRCLE 479 ON READER SERVICE CARD

BlueLynx by Techland Systems


Interface disk subsystem

A removable cartridge **Winchester disk subsystem** that provides removable data storage and data security, and allows effective multiuse of a PC/AT has been anounced by **Interface, Inc.** Because the unit is removable, the incidence of damaged or erased data can be minimized since the user simply removes the disk cartridge when finished working on a particular program. Designed for the AT, which functions as a multiuser/multitasking machine, the removable Winchester disk cartridge complements the AT's capabilities. With 10.5MB of formatted storage per cartridge, the cartridge drive fits into the B: drive slot of the AT. The drive has a track-to-track access time of 22.5 milliseconds and an average access time of 98 ms, including head settling time. Price: $1,695.
Interface, Inc., 21101 Osborne Street, Canoga Park, CA 91304; 818/341-7914
CIRCLE 481 ON READER SERVICE CARD

Techland Systems, Inc. has announced four products that allow the PC/AT to emulate 5251 remote terminal functions and 3270 terminal functions in the remote, coax, and gateway environments. The **BlueLynx 3270** SNA/SDLC links an AT to an IBM 43xx, 30xx, or 370 mainframe using synchronous or asynchronous protocols over leased or switched lines. **BlueLynx 3270 Coax** links an AT to an IBM 43xx, 30xx or 370 mainframe in the local environment. The **BlueLynx 3270 Gateway** allows a single local area network AT to act as a 3274 controller and communicate synchronously with IBM mainframes through modems. The **BlueLynx 5251** links an AT to an IBM S/34, S/36, and S/38 using synchronous protocols over leased or switched lines. Prices: 3270 SNA/SDLC, $945; 3270 Coax, $1,295; 3270 Gateway, $1,195; 5251, $745.
Techland Systems, 25 Waterside Plaza, New York, NY 10010; 212/684-7788
CIRCLE 485 ON READER SERVICE CARD

The **Solidrive 1** is a bubble memory cartridge system announced by **Targa Electronics** for use on computers in harsh environments, including high-dust levels, extreme temperatures, or high humidity. The system is designed for robotics, machine control, and process control applications. Solidrive 1 consists of a cartridge holder in half-height, 5¼-inch drive configuration, a removable bubble memory cartridge, and an interface card for the PC. The interface card installs into one of the PC's expansion slots and replaces an existing floppy-disk controller. It is available in two versions: PC1 controls up to four bubble memory Solidrives; PC2 controls up to four drives in any combination of Solidrives and floppy-disk drives. Prices: 256KB system, $1,270; 384KB system, $1,630; 512KB, $1,995.
Targa Electronics Systems Inc., 3101B Hawthorne Road, Ottawa, Ontario, Canada K1G 3H9; 613/731-9941
CIRCLE 489 ON READER SERVICE CARD

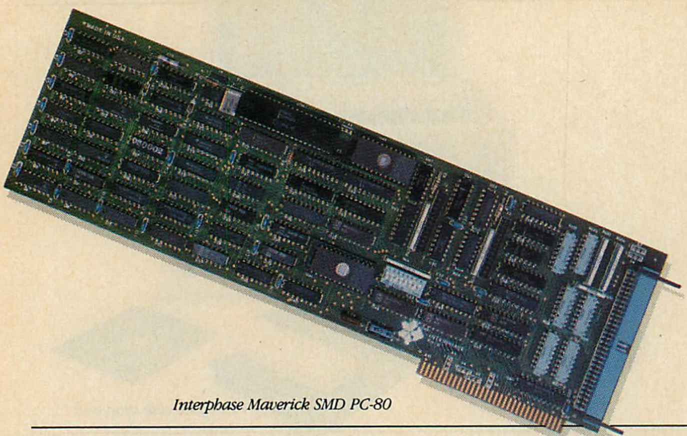
Solidrive 1

Corvus Systems, Inc. now offers a low-cost, 10MB add-in drive for the PC. With the **Corvus Internal Fixed Disk Drive** for the PC, users can have the mass storage offered by a PC/XT. Designed to fit a half-height, 5¼-inch Winchester disk drive format, the Corvus Internal Fixed Disk Drive is easily installed in the PC's compartment designated for a second floppy-disk drive. As with floppy drives, the Corvus add-in drive draws only 13 watts of power, eliminating the need for the external power supply other add-in and add-on Winchester drives require. $995.
Corvus Systems, Inc., 2100 Corvus Drive, San Jose, CA 95124; 408/559-7000
CIRCLE 482 ON READER SERVICE CARD

The **Opus516 Personal Mainframe** from **Opus Systems** is a UNIX/coprocessor subsystem designed to convert an IBM PC to a 32-bit UNIX workstation. It consists of a complete port of AT&T UNIX System V and a 32-bit coprocessor for the PC and plug-compatible computers. Opus516 is based on National Semiconductor's 32016 CPU and includes the 32082 memory management unit and 32081 floating-point unit. On-board memory is expandable to 2MB. 1MB configuration, $3,140 (OEM).
Opus Systems, Suite 120, 960 San Antonio Road, Los Altos, CA 94022; 415/941-7201
CIRCLE 486 ON READER SERVICE CARD

From **Language Resources Inc.** comes the **PC-68K**, a plug-in CPU board, with software, that adds development support for Motorola's 68000 microprocessor family to the PC/XT and PC/AT. It permits designers to develop and debug code for the 68000 CPU chip. PC-68K provides a symbolic debugger, linker/locator, Motorola-compatible macro assembler, and an IEEE floating point package. Pascal and C compilers and emulator and host communication utilities are available as options. Prices: PC-68K with 256KB RAM, $2,995; 512KB RAM, $3,595; 1,024KB RAM, $4,195. Pascal and C compilers, $895 each; host communications utility, $295; emulator communications utility, $495.
Language Resources Inc., 4885 Riverbend Road, Boulder, CO 80301; 303/449-8087
CIRCLE 487 ON READER SERVICE CARD

Advanced Peripherals, Inc. has announced its new PC-family-based data acquisition system called the **Modular Instrumentation Data Acquisition System** (MIDAS). This system combines the ease of use, modularity, and power of expensive stand-alone products with the low cost and immediate software support of board-level products. The



Interphase Maverick SMD PC-80

GPIB-PC interface by National Instruments

MIDAS consists of a control adapter that plugs into a PC and up to 16 I/O modules. The modules are heavy-duty standalone units powered by either the PC or A/C line, depending on the module type. The distance from a module to the microcomputer can be up to 300 feet. This allows modules to be located in hostile environments while the host PC remains in an office. Software support consists of a PC-DOS device driver, several applications programs, and custom software development aids.

ABIGAIL is a high-performance, data-acquisition add-on board for the PC/AT. The analog section consists of a 32-channel single-ended or 16-channel differential input (jumper selectable) multiplexer that expands to 256 or 128 channels respectively; a software-programmable gain amplifier with four user or factory resistor set gains; a 12-bit A/D converter and two 12-bit D/A converters. Prices: MIDAS, $695; ABIGAIL, approximately $1,000 (available mid-1985).
Advanced Peripherals, Inc., 12650 W. Geauga Plaza, Chesterland, OH 44026; 216/729-3942
CIRCLE 477 ON READER SERVICE CARD

Interphase Corporation's Maverick SMD PC-80 is a high-performance disk drive controller, available alone or integrated into a disk subsystem for the PC and compatibles. Now it provides the PC/AT access to SMD (storage module device) drives. These drives offer as much as five times the speed of a PC/XT that is equipped with a Winchester hard disk. Interphase offers the Maverick controller as part of its RDS 350 and RDS 375 removable disk 50 and 75MB SMD drive subsystems, and with its fixed-disk 590MB drive subsystem, the FDS-590. Because the SMD PC-80 resides on a single board, it occupies only one card slot in the computer's chassis. $1,295.
Interphase Corporation, 2925 Merrell Road, Dallas, TX 75229; 214/350-9000
CIRCLE 484 ON READER SERVICE CARD

National Instruments has announced new hardware and software products for the PC family and compatibles. Further, the **GPIB-PC2A** and **Revision C** software are completely compatible with the IBM General Purpose Interface Bus Adapter. This interface from National Instruments is the most recent in its family of GPIB interfaces. These interfaces allow computers to control 4,000 IEEE-488 programmable instruments available from more than 500 vendors for engineering, scientific, CAD/CAM, and medical applications.

The GPIB-PC2A interface is a half-height board that complies with all of the IBM expansion slot specifications, enabling it to fit into any available slot, including the short slots in the IBM Portable PC. Like its predecessors, the new board is based upon the NEC uPD7210 GPIB controller chip and a programmable logic array providing the most complete set of GPIB functions in the hardware with a minimum number of circuit elements. The new Revision C software package is designed to run on the GPIB-PC2A, as well as the IBM GPIB Adapter. A unique feature of the Revision C software is that it will automatically configure itself to run on a variety of compatible systems. Prices: GPIB-PC2A, $385; equivalent kit with realtime clock, $485; Revision C software kit, $75; language interfaces, $50 each.
National Instruments, 12109 Technology Blvd., Austin, TX 78727; 800/531-5066; in Texas, 512/250-9119
CIRCLE 483 ON READER SERVICE CARD

The **TIAC Network Processing System (NPS)** is a hardware/software system designed to operate independently of or in conjunction with a PC while providing a smart network interface. The NPS consists of a base processor (PC-424) and four optional submodules: bus extender, a LAN generic interface, video graphics and keyboard interface, and four-serial-channel interface. The network I/O coprocessor is a max mode 8088-based, plug-in adapter that takes up one PC expansion slot. The **PC-424** is designed to relieve the host processor of all higher level protocol processing responsibilities associated with multiple serial lines, networking, and cipher operations. Four serial channels are provided on board. The PC communicates with the PC-424 via a high-speed DMA-controlled FIFO (thus allowing arbitrarily large message sizes). With the addition of a video graphics and keyboard interface module, both of which are compatible with the PC, the PC-424 becomes a stand-alone PC. Optional plug-on adapter modules expand the basic functionality of the PC-424. $845.
TIAC Manufacturing Incorporated, 3084 Spring Street, Port Moody, B.C., Canada V3H 1Z8; 604/461-1626
CIRCLE 478 ON READER SERVICE CARD

SOFTWARE

The **BYSO SOFT WINCHESTER** program, by the **Levien Instrument Company**, is an inexpensive software alternative to a hard disk. Once loaded on a system disk, it is transparent. The program stores the most frequently used data in RAM memory, where it can be accessed quickly, and loads many programs faster than from a hard disk. Its large storage capacity allows the use of 1,440KB of data; if data are needed that cannot be accessed from the RAM or disk, the program will ask for the disk with the data to be inserted. SOFT WINCHESTER provides protection for data: it automatically backs up all data to floppy disk. It is also removable—just press a key combination and use new sets of 1,440KB of data (four floppy disks). $60.
Levien Instrument Company, P.O. Box 31E, McDowell, VA 24458; 703/396-3345
CIRCLE 459 ON READER SERVICE CARD

They said it couldn't be done. Borland Did It. Turbo Pascal 3.0

The industry standard

With more than 250,000 users worldwide Turbo Pascal is the industry's de facto standard. Turbo Pascal is praised by more engineers, hobbyists, students and professional programmers than any other development environment in the history of microcomputing. And yet, Turbo Pascal is simple and fun to use!

	TURBO 3.0	TURBO 2.0	MS PASCAL
COMPILATION SPEED	8.1	16	206
EXECUTION SPEED	9 SEC	13 SEC	20 SEC
CODE SIZE	12 K	12 K	35 K
BUILT-IN INTERACTIVE EDITOR	YES	YES	NO
ONE STEP COMPILE (NO LINKING NECESSARY)	YES	YES	NO
COMPILER SIZE	39K	35K	300K+
TURTLE GRAPHICS	YES	NO	NO
BCD OPTION	YES	NO	YES
PRICE	$69.95	$54.95	$295.00

(*) **Benchmark** run on an IBM PC using MS Pascal version 3.2 and the DOS linker version 2.6. The 179 line program used is the "Gauss-Seidel" program out of Alan R. Miller's book: *Pascal programs for scientists and engineers* (Sybex, page 128) with a 3 dimensional non-singular matrix and a relaxation coefficient of 1.0.

The best just got better: Introducing Turbo Pascal 3.0

We just added a whole range of exciting new features to Turbo Pascal:

- First, the world's fastest Pascal compiler just got faster. Turbo Pascal 3.0 (16 bit version) compiles twice as fast as Turbo Pascal 2.0! No kidding.
- Then, we totally rewrote the file I/O system, and we also now support I/O redirection.
- For the IBM PC versions, we've even added "turtle graphics" and full tree directory support.
- For all 16 Bit versions, we now offer two additional options: 8087 math coprocessor support for intensive calculations and Binary Coded Decimals (BCD) for business applications.
- And much much more.

The Critics' Choice.

Jeff Duntemann, PC Magazine: *"Language deal of the century . . . Turbo Pascal: It introduces a new programming environment and runs like magic."*

Dave Garland, Popular Computing: *"Most Pascal compilers barely fit on a disk, but Turbo Pascal packs an editor, compiler, linker, and run-time library into just 39K bytes of random-access memory."*

Jerry Pournelle, BYTE: *"What I think the computer industry is headed for: well documented, standard, plenty of good features, and a reasonable price."*

Portability.

Turbo Pascal is available today for most computers running PC DOS, MS DOS, CP/M 80 or CP/M 86. A XENIX version of Turbo Pascal will soon be announced, and before the end of the year, Turbo Pascal will be running on most 68000 based microcomputers.

An Offer You Can't Refuse.

Until June 1st, 1985, you can get Turbo Pascal 3.0 for only $69.95. Turbo Pascal 3.0, equipped with either the BCD or 8087 options, is available for an additional $39.95 or Turbo Pascal 3.0 with both options for only $124.95. As a matter of fact, if you own a 16-Bit computer and are serious about programming, you might as well get both options right away and save almost $25.

Update policy.

As always, our first commitment is to our customers. You built Borland and we will always honor your support.

So, to make your upgrade to the exciting new version of Turbo Pascal 3.0 easy, we will accept your original Turbo Pascal *disk* (in a bend-proof container) for a trade-in credit of $39.95 and your Turbo87 original *disk* for $59.95. This trade-in credit may only be applied toward the purchase of Turbo Pascal 3.0 and its additional BCD and 8087 options (trade-in offer is only valid directly through Borland and until June 1st, 1985).

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6

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Borland Does It Again: SuperKey $69.95

Sure, ProKey™ is a nice little program. But when the people who brought you Turbo Pascal and SideKick get serious about keyboard enhancers, you can expect the impossible . . . and we deliver.

	ProKey	SuperKey
ALL FEATURES RESIDENT IN RAM AT ALL TIMES	NO	YES
RESIDENT PULL-DOWN MACRO EDITOR	NO	YES
RESIDENT FILE ENCRYPTION	NO	YES
PROKEY COMPATIBILITY	YES	YES
DISPLAY PROTECTION	NO	YES
ABILITY TO IMPORT DATA FROM SCREEN	NO	YES
PULL-DOWN MENU USER INTERFACE	NO	YES
CONTEXT-SENSITIVE ON-LINE HELP SYSTEM	NO	YES
DISPLAY-ONLY MACRO CREATION	NO	YES
ENTRY AND FORMAT CONTROL IN DATA FIELDS	NO	YES
COMMAND KEYS REDEFINABLE "ON THE FLY"	NO	YES
PRICE	129.95	69.95

Total ProKey compatibility. Every Prokey Macro file may be used by SuperKey *without change* so that you may capitalize on all the precious time you've invested.

Now your PC can keep a secret! SuperKey includes a resident file encryption system that uses your password to encrypt and decrypt files, even while running other programs. Two different encryption modes are offered:

1. Direct overwrite encryption (which leaves the file size unchanged) for complete protection. At no point is a second file that could be reconstructed by an intruder generated. Without your secret password, no one will ever be able to type out your confidential letters again!

2. COM or EXE file encryption which allows you to encrypt a binary file into an ASCII file, transmit it through a phone line as a text file and turn it back again into an executable file on the target machine (only of course if your correspondent knows the secret password!). Now, you will even be able to secretly exchange programs through Public Bulletin Board Systems or services such as CompuServe.

Totally memory resident at all times, gives SuperKey the ability to create, edit, save and even recall new or existing macro files anytime, even while running another program.

Pull down macro editor. Finally, a sensible way to create, edit, change and alter existing macro definitions. Even while using another application, a simple keystroke instantly opens a wordprocessor-like window where you're allowed to see, edit, delete, save and even attach names to an individual macro or file of macros, and much more.

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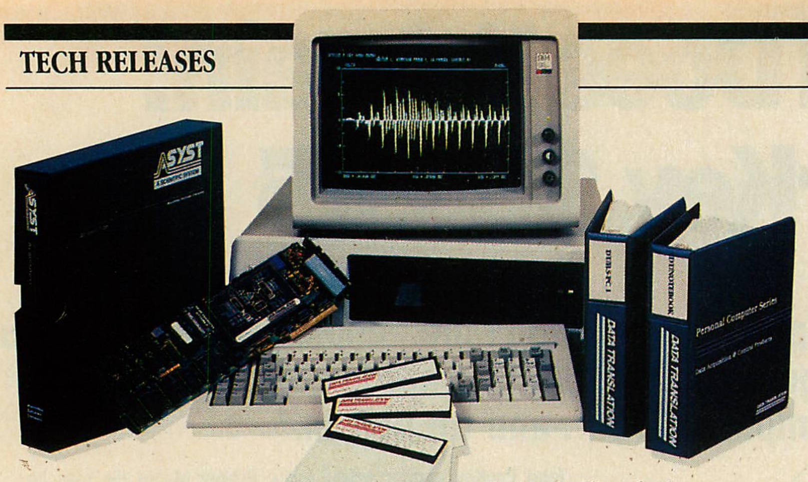


The Data Translation family

QUICKREPORT

DT/NOTEBOOK, DT/ILS-PC 1, and **ASYST** are three software packages from **Data Translation, Inc.** to support its family of IBM PC-compatible data acquisition and control boards. They are suitable for such applications as chromatography, physiological and speech research, materials testing, and industrial control. Users are not required to write original programs. DT/NOTEBOOK is an integrated, menu-driven software package for realtime data acquisition, process control, data analysis, and graphics display. DT/ILS-PC 1 is an interactive, command-driven, digital signal processing package. ASYST is advanced, command-driven software for realtime data acquisition and control, data analysis, and graphics displays. Prices: DT/NOTEBOOK, $795; DT/ILS-PC 1, $1,495; ASYST, $1,695.
Data Translation, 100 Locke Drive, Marlboro, MA 01752; 617/481-3700
CIRCLE 476 ON READER SERVICE CARD

Borland International has introduced **SuperKey**, a RAM-resident enhancement software program with macro processing and automatic data encryption features. SuperKey will run on the PC, PC/XT, PC/AT, PC*jr*, and compatibles. Users can define, edit, save, load, and recall macros in realtime. SuperKey's resident full-screen macro editor can be "pulled down" on top of the main program; it allows manipulation of macro files in a manner transparent to the main program. The command stack has a capability to recall automatically the last 20 entered commands; the user can select one or more commands to be edited and reused, even at the DOS command level. Two modes of data encryption are supported: direct-overwrite protection and textfile mode, which enables users to encrypt binary files. Price: $69.95.
Borland International, 4113 Scotts Valley Drive, Scotts Valley, CA 95066; 408/438-8400
CIRCLE 469 ON READER SERVICE CARD

Fox & Geller has released **QUICKREPORT**, a report writer for Ashton-Tate's dBASE II and dBASE III. QUICKREPORT is a powerful, yet easy-to-use report writer that can produce the most simple or complex reports for dBASE III. It requires no programming, combining up to six dBASE III databases in one report. Reports can include user-defined calculations on data, perform group breaks on up to 16 different fields, and select data using criteria entered by the user. A high-speed sort is also built into the product. QUICKREPORT runs on the PC and compatibles and requires 256KB memory. Price: $295.
Fox & Geller, Inc., 604 Market Street, Elmwood Park, NJ 07407; 201/794-8883
CIRCLE 475 ON READER SERVICE CARD

A new **duplication and copy-protection kit** has been released by **Softguard Systems, Inc.** The kit allows software developers to duplicate, protect, and serialize their products in a convenient manner in conjunction with their PC or PC/XT. It puts the control of program use and distribution in the hands of the person most concerned about the intellectual investment. Besides sophisticated protection and serialization, the product is capable of providing copy-protected back-up copies and allows the protected product to be transferred and operational on hard disk without reintroducing the distribution floppy into the drive. $575.

The newest update of **Framework (version 1.1)**, by **Ashton-Tate**, will now include a copy of the Softguard protection system; version 1.1 gives full support to the PC/AT. According to Ashton-Tate, the new copy-protection system makes the product easier to use by allowing Framework to be completely installed on a hard disk. It no longer will be necessary to use a key disk each time the software is loaded from a hard disk. Framework 1.1 replaces an earlier scheduled release. $695.
Softguard Systems, Inc., 2840 San Tomas Expressway, Suite 201, Santa Clara, CA 95051; 408/970-9240

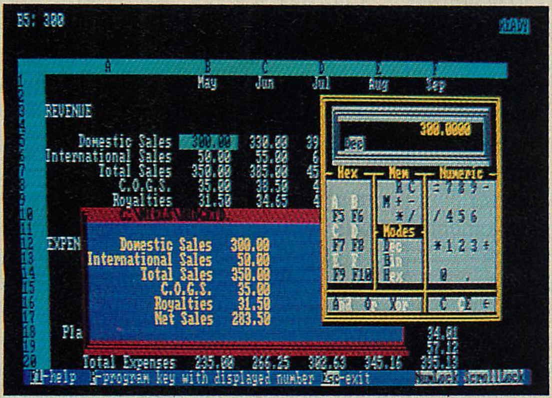
Ashton-Tate, 10150 W. Jefferson Blvd., Culver City, CA 90230; 213/204-5570
CIRCLE 457 ON READER SERVICE CARD

A new utility program for the PC called **PC-USAGE** has been released by **Stilwell Software Products**. The 1985 tax laws require computer users to record their usage of the computer if they want to deduct any business portion of the computer on their taxes. PC-USAGE can help users meet this requirement. The program is started at the beginning of each session with the computer in one of two ways: if an AUTOEXEC.BAT file is used, PC-USAGE can be included in that file; otherwise, the user just types the word *usage* when the computer is started up. Once started, the program automatically retrieves the system date and time. It also checks to see if the record of the last session had an end time, if not, the user is given the opportunity to fill it in; it includes a remark area as well. The program also records whether the session is business-related or personal. On request, PC-USAGE provides the user with a report that lists all usage of the computer as well as the total time of computer usage and the present business usage and personal usage. $24.95.
Stilwell Software Products, 16403 N. 43rd Drive, Glendale, AZ 85306; 602/978-4678
CIRCLE 465 ON READER SERVICE CARD

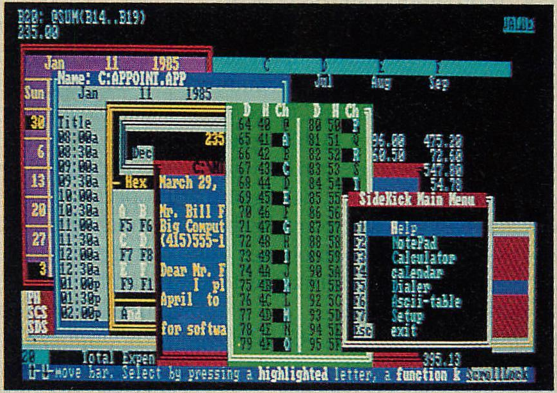
Softaid's MTBASIC is a new multitasking BASIC compiler for both PC-DOS and CP/M-80 systems. MTBASIC can create as many as 10 windows on the screen simultaneously; each window can be assigned a separate task, or multiple windows can be assigned to each task. The product's most unique feature is that it supports multitasking programs: a maxi-

Borland's SideKick Software Product of the Year*

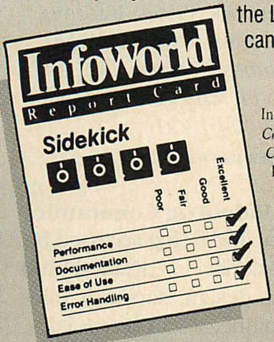
SideKick is InfoWorld Software Product of the Year. It won over Symphony. Over Framework. Over ALL the programs advertised in this magazine. Including, of course, all the "fly-by-night" SideKick imitations. SideKick . . . . Simply the best.



Here's **SideKick** running over Lotus 1-2-3. In the SideKick **Notepad** you'll notice data that's been imported directly from the Lotus screen. In the upper right you can see the **SideKick Calculator**.



All the **SideKick** windows stacked up over Lotus 1-2-3. From bottom to top: SideKick's **"Menu Window"**, **ASCII table**, **Notepad**, **Calculator**, **Appointment Scheduler/Calendar**, and **Phone Dialer**. Whether you're running WordStar, Lotus, dBase, or any other program, SideKick puts all these desktop accessories instantly at your fingertips.



InfoWorld Report Card 1984 by Popular Computing, Inc., a subsidiary of CW Communications Inc. Reprinted from InfoWorld, 1060 Marsh Road, Menlo Park, CA 94025.

Jerry Pournelle, BYTE: *"If you use a PC, get SideKick. You'll soon become dependent on it."*

Garry Ray, PC Week: *"SideKick deserves a place in every PC."*

Charles Petzold, PC Magazine: *"In a simple, beautiful implementation of WordStar's block copy commands, SideKick can transport all or any part of the display screen (even an area overlaid by the notepad display) to the notepad."*

Dan Robinson, InfoWorld: *"SideKick is a time-saving, frustration-saving bargain . . . ."*

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*Selected by *InfoWorld* as the most significant software product of the year.

CIRCLE NO. 117 ON READER SERVICE CARD

Informix-SQL and ESQL/C by RDS

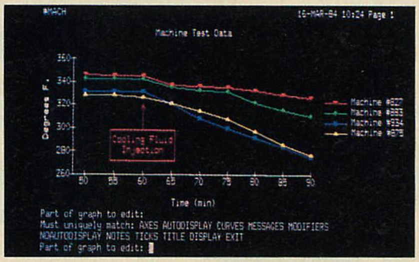
Action Diagrammer by DDI

mum of 10 programs can run concurrently. In addition to simple multitasking, tasks also can be started upon receipt of hardware interrupts, permitting true interrupt-driven device I/O from BASIC. MTBASIC generates highly optimized object code. Because it runs interactively, like an interpreter, debugging is quick and easy. MTBASIC provides high-level hooks for the addition of user I/O devices so that powerful formatted I/O can be performed. $49.95.
Softaid, Inc., P.O. Box 2412, Columbia, MD 21045-1412; 301/792-8096
CIRCLE 473 ON READER SERVICE CARD

Action Diagrammer, by **Database Design, Inc.**, is a new editor that allows analysts and programmers to create and edit structured diagrams in English, structured English, fourth generation languages, and almost any programming language. Action Diagrammer can be used on the PC or any 100-percent compatible. Its diagrams combine graphic and narrative notations to represent program logic in an easy-to-understand format. Unlike other diagramming techniques, action diagramming is complete and rigorous enough to represent both high-level system overviews and detailed program logic. With Action Diagrammer and a terminal emulator or 3270-PC, a user can upload and download programs between the PC and a larger host computer. $495.
Database Design, Inc., 2020 Hogback Road, Ann Arbor, MI 48104; 800/237-1977; in Michigan, 800/447-3556
CIRCLE 474 ON READER SERVICE CARD

BBN Software Product Corporation and **Laboratory Technologies Corporation** have announced the integration of **RS/1**, BBN's data analysis system, and **LABTECH NOTEBOOK**, Laboratory Technology's data acquisition system. The combined system, available on the PC, PC/XT, and PC/AT, provides a seamless computing environment that enables scientists and engineers to acquire and analyze data without the need for special programming. LABTECH NOTEBOOK is an integrated software package for data acquisition, monitoring, and real-time control. Menu-driven, it reduces complicated procedures to single-button operations. RS/1 provides high-level capabilities, including data management and analysis, curve fitting, statistics, graphics, modeling, and reporting. LABTECH NOTEBOOK, $795; RS/1, $2,000.
Laboratory Technologies Corporation, 255 Ballardvale Street, Wilmington, MA 01887; 617/657-5400

BBN Software Products Corporation, One Alewife Place, Cambridge, MA 02140; 800/251-1717; in Massachusetts, 617/491-8488
CIRCLE 472 ON READER SERVICE CARD



RS/1 screen

Relational Database Systems, Inc. has called for standardizing on IBM's SQL (standard query language) for all database programming and, in support of such a call, has announced that it will share some of its own source code with systems developers. In conjunction with the announcement, RDS has unveiled two new products embodying SQL: **Informix-SQL** and **Informix-ESQL/C**. The company feels that without standardization, "billions of dollars will be wasted by business and government and other computer users, because database expertise will be fragmented over many different database languages, when only one is needed."

Informix-SQL is a new database applications development product derived from RDS's flagship product, Informix. The new product runs on a wide range of UNIX-based micros, minis, and mainframes; it provides high-level tools to define and use custom data entry and query screens, as well as custom reports. A PC-DOS version will be available shortly. Informix-ESQL/C provides SQL query statements to access databases from C programs. Each is available in either a full-development version or separately as a run-only version to be embedded in vertical (canned) applications. Both products will be distributed through RDS's OEMs, VARs, and distribution network. Prices: Informix-SQL, $1600; Informix-ESQL/C, $1,200.
Relational Database Systems, Inc., 2471 E. Bayshore Road, Suite 600, Palo Alto, CA 94303; 415/424-1300
CIRCLE 470 ON READER SERVICE CARD

VideoLog, by **VideoLog Communications**, is on-line and being accessed by industry professionals for detailed product information: design, standards, and components engineers can access current data on more than 500,000 semiconductors, search on key parameters, connect directly to manufacturers via InfoGram electronic mail, and have access to a directory of 14,000 suppliers. The system is accessible by a local telephone call using a nationwide data network. Basic services at $15 per hour include key word, type number, catalogue, and directory searches. For value-added service, including component property displays, functional equivalence, and parametric searches, the user charge is $39 per hour. In Canada, VideoLog is available for a $10-per-hour network surcharge via the Datapac gateway into CompuServe.
VideoLog Communications, 50 Washington Street, Norwalk, CT 06854; 203/838-5100
CIRCLE 450 ON READER SERVICE CARD

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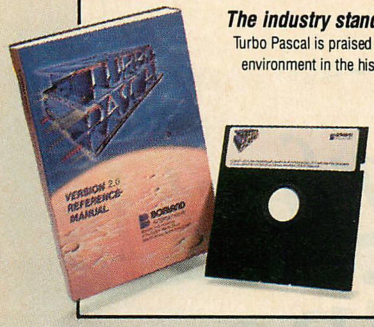

The industry standard. With more than 250,000 users worldwide Turbo Pascal is the industry's de facto standard. Turbo Pascal is praised by more engineers, hobbyists, students and professional programmers than any other development environment in the history of microcomputing. And yet, Turbo Pascal is simple and fun to use!

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Jeff Duntemann, PC Magazine: *"Language deal of the century . . . Turbo Pascal: It introduces a new programming environment and runs like magic."*

Dave Garland, Popular Computing: *"Most Pascal compilers barely fit on a disk, but Turbo Pascal packs an editor, compiler, linker, and run-time library into just 29K bytes of random-access memory."*

Jerry Pournelle, BYTE: *"What I think the computer industry is headed for: well documented, standard, plenty of good features, and a reasonable price."*

Portability. Turbo Pascal is available today for most computers running PC DOS, MS DOS, CP/M 80 or CP/M 86. A XENIX verison of Turbo Pascal will soon be announced, and before the end of the year, Turbo Pascal will be running on most 68000 based microcomputers.

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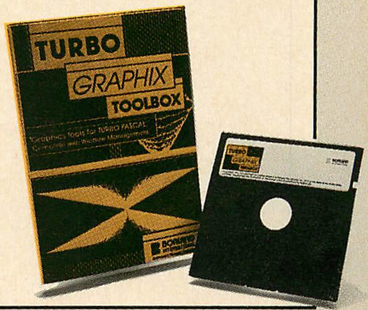
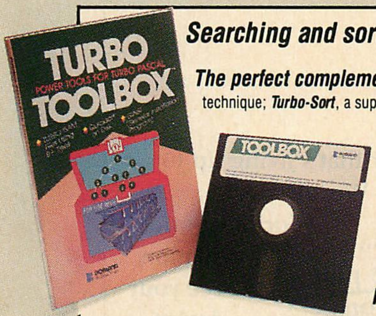
No sweat and no royalties. You may incorporate part, or all of these tools in your programs, and yet, we won't charge you any royalties. Best of all, these functions and procedures come complete with commented source code on disk ready to compile!





Searching and sorting made simple

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The perfect complement to Turbo Pascal. It contains: ***Turbo-Access***, a powerful implementation of the state-of-the-art B+tree ISAM technique; ***Turbo-Sort***, a super efficient implementation of the fastest data sorting algorithm, "Quicksort on disk". And much more.

Jerry Pournelle, BYTE: "The tools include a B+tree search and a sorting system; I've seen stuff like this, but not as well thought out, sell for hundreds of dollars."

Get started right away: free database! Included on every Toolbox disk is the source code to a working data base which demonstrates how powerful and easy to use the Turbo-Access system really is. Modify it to suit your individual needs or just compile it and run.

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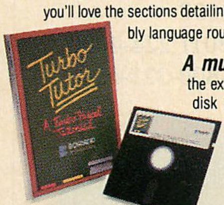

A must. You'll find the source code for all the examples in the book on the accompanying disk ready to compile. Turbo Tutor might be the only reference on Pascal and programming you'll ever need.

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CIRCLE NO. 118 ON READER SERVICE CARD

All in all, WordPerfect is absolutely stunning.

PC Magazine

In the beginning, the creators of WordPerfect set out to design the perfect word processing software for business. Along the way, they tested each new function on the very secretaries who would eventually be using it. Thanks to them, the product lives up to its name: WordPerfect.

Easy.

Learning WordPerfect's basic text editing functions is quick and simple. Plus, comprehensive documentation and simple practice exercises help even beginners master WordPerfect's many other functions easily.

WordPerfect is a word processor for business applications.

PC World

Fast.

With WordPerfect's document orientation, you never have to wait between pages of text. No matter how fast you type, WordPerfect won't slow you down.

WordPerfect makes putting together a professional-looking balance sheet or financial report easy.

BYTE

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In addition to standard word processing functions, WordPerfect includes many extra business features, such as a 100,000-word phonetic dictionary; table and index generation; multi-page footnoting; automatic outlining and paragraph numbering; and a network version. Get the business word processor that's living up to its name. WordPerfect.

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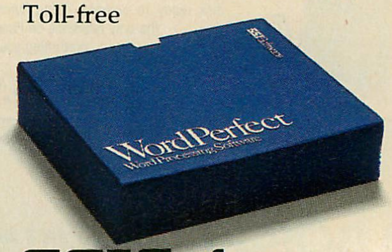

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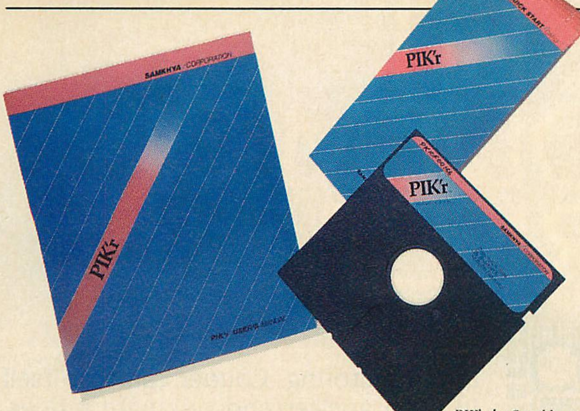


PIK'r by Samkhya

STATA by CRC

Samkhya Software Corporation has announced the availability of its first productivity tool for bridging the communications gap between incompatible software programs on the PC and compatibles. The new product, **PIK'r**, is a full-screen data editor that allows users to choose the data they want to use from any report and easily reformat the data for transfer between database management software, spreadsheets, and word processors. The program also allows ASCII files generated by mainframe programs to be formatted for use by PC applications; it features a state-of-the-art "human" interface and supports a mouse. The PIK'r screen-oriented editing features let any PC user scroll easily through long reports, choose the data required, and then transfer the data to the format that is required. $95.
Samkhya Software Corporation, P.O. Box 142, Petaluma, CA 94953; 800/442-0012; in California, 800/442-5544

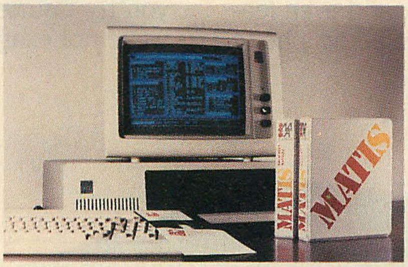
CIRCLE 467 ON READER SERVICE CARD

STATA by **Computer Resource Center** is a program that helps users manage, display, and analyze data. It has features in common with spreadsheet programs, database management programs, statistical packages, and programming languages. STATA is interactive, making it possible to answer the "what if" questions that spreadsheets handle so well, without rigid restrictions on the organization of data. It allows the user to create complex data sets, transform them in almost any way desired, and locate particular pieces of information. STATA performs a variety of statistical analyses, including multivariate regression; and, like a programming language, it allows the user to store groups of STATA commands so that complicated analyses can be automated. $395.
Computing Resource Center, 10801 National Boulevard, Los Angeles, CA 90064; 213/470-4341

CIRCLE 466 ON READER SERVICE CARD

Softway, Inc. has introduced **MATIS**, an applications development tool that allows programmers to design sophisticated screens and incorporate them into their programs. MATIS is a collection of assembly language subroutines providing the ability to design data entry/display screens of almost unlimited size, to create windows for single- or multiple-screen display, and to manage the created screens when the application is run. Screens are referenced by names; they may be saved on disk and even printed directly. MATIS runs on the PC, PC/XT, and true compatibles with DOS and 128KB of RAM. It is interfaced with most popular languages, including interpreted and compiled BASIC, Pascal, C, and assembly language. $150.
Softway, Inc., 500 Sutter Street, Suite 222, San Francisco, CA 94102; 415/397-4666

CIRCLE 471 ON READER SERVICE CARD



MATIS by Softway

Microsoft COBOL version 2.0 has been released by **Microsoft Corporation**. This new version has been tested and certified by the U.S. Government's General Services Administration Federal Software Testing Center at the high level of compliance with the ANSI 74 level 2 standard. New features of Microsoft COBOL include multikey ISAM (indexed sequential access method), dynamic call and cancel, and built-in sort/merge. Version 2.0 brings capabilities previously found only in mainframe versions of COBOL to microcomputers that use MS-DOS, thus making it possible for micros to be used in the development of COBOL applications for mainframes and for mainframe COBOL applications to be moved to micros. $700.
Microsoft Corporation, 10700 Northup Way, Box 97200, Bellevue, WA 98009; 206/828-8080

CIRCLE 468 ON READER SERVICE CARD

RTCS/Real-Time Computer Science Corporation has announced several new products. With the first, RTCS has configured Intel's iRMX86 operating system to IBM device driver specifications to offer a realtime multitasking operating system: **PC/RTX** includes facilities for executing programs concurrently, sharing resources and information, servicing asynchronous events, and interactively controlling system resources and utilities. Price: $1,000.

Version 5.0 of the **RTCS/UDI** has been released; it is an implementation of Intel's Universal Development Interface, which allows software developers to run Intel programming languages and utilities on the PC and PC/XT, and now the PC/AT. Version 5.0 enhances previous versions making the software 100-percent compatible with Intel's 16-bit software products. $500.

Another product allows software developers utilizing Intel's 8-bit software to run Intel programming languages on the PC or PC/XT. Unlike other 8-bit operating systems that are on the market, no additional hardware is required to run **iSIM85**, leaving valuable expansion slots free. $500.
RTCS/Real-Time Computer Science Corporation, 1390 Flynn Road, Unit E, Camarillo, CA 93010; 805/987-9781

CIRCLE 458 ON READER SERVICE CARD

Correction: The January 1985 Tech Releases section included an item on a software product called **Simulations**, by **Actuarial Micro Software**. The company's telephone number should read 919/765-5588.

BIT FOR BIT THE BEST MODEM ON THE MARKET.

Other people make modems for telecommunications. But our new Courier 2400™ modem is made for business. This modern modem transmits, over the phone, 240 characters a second, enabling you to upload or download data at twice the speed of a 1200 bps modem. You'll cut phone costs, save precious hours and increase productivity.

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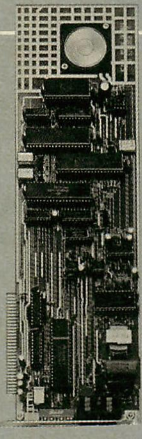
Help Screens

Courier 2400 is accommodating in other ways too. It lets you know the length of each call, tells you (on screen) the status of a call in progress, and even features an adjustable speaker to provide audio phone line monitoring. Courier can test itself in both answer and originate modes, and automatically adjusts from 2400 bps to 1200 or 300 bps. And a powerful automatic equalizer assures nearly perfect performance on every call.



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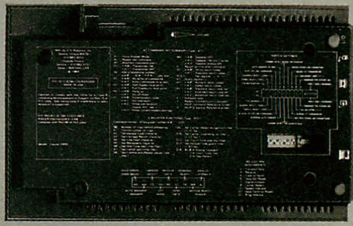
And to get the most out of either Courier or Microlink, ask for new, improved Telpac telecommunications software with easy to use windows.



Bottom of Courier

We set out to build the best modem on the market. Now, it's ready. Once you try Courier or Microlink, we think you'll agree—we're not exaggerating one bit.

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CIRCLE NO. 237 ON READER SERVICE CARD

KEVIN M. CRENSHAW

Rev Up the AT Keyboard

The PC/AT's flexible hardware allows the user to speed up key response.

Does it sometimes seem to take forever to move the cursor in a text editor or word processor? This is usually not the fault of the software. The real culprit is the keyboard hardware that controls the repeat speed of the arrow keys (and all other keys, for that matter). Not much can be done to help the owner of a PC or a PC/XT, but PC/AT owners are in luck. IBM designed the AT keyboard interface with a lot more flexibility, and part of that flexibility is a capability that allows the user to speed up the keyboard.

The features available via the AT's keyboard interface are explained in the PC/AT *Technical Reference Manual*. Unfortunately, finding out exactly how to invoke those features is an exercise only Sherlock Holmes would enjoy. Not only is the documentation obscure in that area, but someone cut a gaping hole out of the middle of the ROM BIOS listing, and the routine that communicates with the keyboard controller is among the missing or wounded. Once the mess is sorted out, however, it turns out to be a fairly simple task to change the behavior of an AT keyboard.

The first factor that controls repeat speed is *delay*, which determines how long the key must be held down before it will begin repeating. A long delay insures that keys are not repeated unintentionally. The second factor is *typematic rate*, which determines the repeat frequency once the delay requirement has been satisfied. On the PC/AT keyboard, the delay can range from .25 to 1.25 seconds, and the typematic rate is adjustable from 30 characters per second to 2 characters per second. The default is .5 seconds of delay with a typematic rate of 10 characters per second. These factors are controlled by the program shown in the listing below.

Kevin M. Crenshaw is a software engineer at SSI in Orem, Utah, where he works on enhancements for WordPerfect. He has a bachelor of science in physics from Brigham Young University.

LISTING: SETKEY.COM

```
;name: setkey.asm (setkey.com) by kevin m. crenshaw
cseg    segment
assume  cs:cseg,ds:cseg
org     100h
;------ get typematic rate:  a to z, [, \, ], ^, _, or '
start:  mov     si,81h          ;point to command line
        xor     bx,bx           ;set default
letter: lodsb                   ;get first non-space char
        cmp     al," "
        je      letter
        jb      send            ;end of line, use default
        dec     al
        and     al,0dfh         ;upper case
        sub     al,"@"          ;valid letter or symbol?
        jnb     lettr1          ;  maybe
        dec     si              ;  no, might be a digit
        jmp     short digit
lettr1: cmp     al,31           ;valid letter or symbol?
        ja      error2          ;  no, error
        xchg    al,bl           ;  yes, save as typematic rate
;------ get delay value:  1 to 4
digit:  lodsb                   ;get next non-space char
        cmp     al," "
        je      digit
        jb      send            ;end of line, use what we have
        sub     al,"1"          ;valid digit?
        jb      error2          ;  no, error
        cmp     al,3            ;valid digit?
        ja      error2          ;  no, error
        mov     cl,5            ;  yes, save as delay value
        shl     al,cl
        or      bl,al
;------ send values to keyboard
send:   mov     al,0f3h         ;set typematic/delay
        call    xmit            ;command accepted?
        jcxz    error1          ;  no, error
        xchg    al,bl           ;send typematic/delay values
        call    xmit            ;values accepted?
        jcxz    error1          ;  no, error
        int     20h             ;return to dos
;------ bad input
error1: mov     dx,offset error1$       ;hardware error
        jmp     short error
error2: mov     dx,offset error2$       ;bad input error
error:  mov     ah,9                    ;print message
        int     21h
        int     20h
error1$ db      "Hardware error",13,10,"$"
error2$ db      "Valid parameters are A-Z, then 1-4",13,10,"$"
;xmit - send data to keyboard
;in:    al      - data to send
;out:   ax      - destroyed
;       cx      - zero if error, nonzero otherwise
xmit    proc    near
        cli                     ;interrupts off
        xchg    al,ah           ;save command
        xor     cx,cx
xmtwt1: in      al,64h
        test    al,2            ;is data waiting for cntrlr?
        loopnz  xmtwt1          ;  yes, wait
        jcxz    xmtret          ;error, cntrlr not reading data
        xchg    al,ah           ;get command back
        out     60h,al          ;send to keyboard
        xor     cx,cx
xmtwt2: in      al,64h
        test    al,2            ;has controller read data yet?
        loopnz  xmtwt2          ;  no, wait
        jcxz    xmtret          ;error, cntrlr not reading data
        xor     cx,cx
xmtwt3: in      al,64h
        test    al,1            ;did keyboard send ACK yet?
        loopz   xmtwt3          ;  no, wait for it
        jcxz    xmtret          ;  error, no response
        in      al,60h          ;get response
        cmp     al,0fah         ;was it ACK?
        je      xmtret          ;  yes
        xor     cx,cx           ;  no, error
xmtret: sti                     ;interrupts back on
        ret
xmit    endp
cseg    ends
        end     start
```

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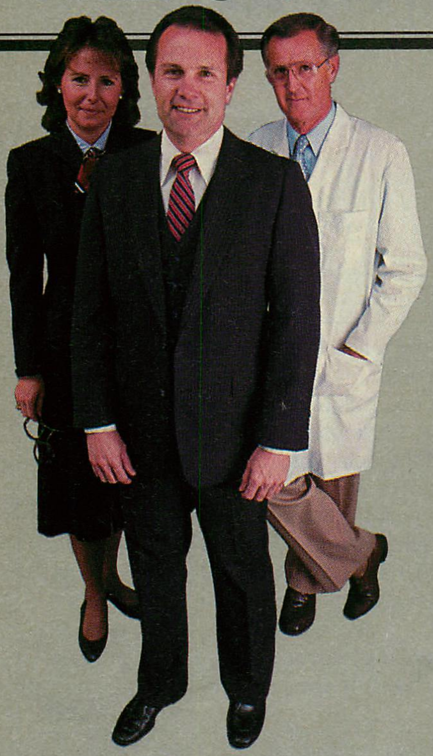

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TECH NOTEBOOK 38

TED MIRECKI

A Bona Fide Bug

Some problems in assembling and linking programs with DOS 2.0 and 2.1 are caused by a bug in the systems software.

When a program fails to compile or link, a programmer first looks for errors in his code rather than blaming the compiler or linker. Systems software is among the most reliable and with the widespread use it gets, any bugs are usually found promptly and reported. Users who have been having trouble linking assembly programs under DOS 2.0 and 2.1 may have reason to blame the system's software—the problem may not be in the code; there is a bona fide bug.

To illustrate such a bug, assemble and link the short program in listing 1. Note that the code is not executable, because it merely allocates data areas. The syntax is perfectly valid and it assembles cleanly, but it generates an "Invalid object file" message from the version 2.x linker. The same object file will link without errors with the version 1.1 linker. The code sequence that generates the error is the allocation of a structure containing an uninitialized double-word, quad-word, or 10-byte field (DD, DQ, or DT pseudo-op with a value of ?). Fields of this length that are allocated directly and not by invocation of a structure cause no problems.

The most obvious way to avoid this problem is to initialize structure fields, either within the structure definition itself or within the angle brackets when the structure is invoked. But sometimes that is not possible, for instance when defining a structure to overlay an area of memory that is written before a program gets control, such as the interrupt vector table or the BIOS data area. In that case, the simplest way out is to define several word or byte fields whose lengths add up to the required four, eight, or ten bytes. This process is illustrated by the program in listing 2: it produces the same memory allocation as listing 1 and will link without problems. (The warning message "No stack segment" may be ignored, since this is not an executable program.)

Although the structures in listings 1 and 2 produce the same memory allocation, they are not strictly equivalent under all conditions. If they were, there would be no need to ever define a double-word field. The differences arise because the assembler, like some high-level languages, associates a type with each label and variable. Suppose that the first two words of structure S1 are to contain a far address: an offset in the first word and a segment in the second. With the structure defined as in listing 1 (assuming it could get through the linker) a jump or call to that far address could be coded as **CALL VAR.FIELD**.

With the structure of listing 2, the above instruction would be interpreted as a near call to the offset contained in the first word of the structure, in the local code segment. This is because the label VAR.FIELD has been declared as a word; the second word of the structure is not logically part of the storage defined by that label. To execute a far call, the instruction must be coded as **CALL DWORD PTR VAR.FIELD**.

Incidentally, I have occasionally found that compiled code (IBM COBOL and Microsoft C) would not link with the version 2.x linker, but would with version 1.1. In these cases, either the compiler generates the equivalent of uninitialized structure fields or there may be some other undiscovered linker bug that is triggered by certain coding structures. Since the programmer can have virtually no control over the structure of an object file produced by a compiler, the only solution is to find a linker version that will work.

A bug in the IBM/Microsoft Assembler (version 1) produces the same symptoms, but for a different reason. The program in listing 3 assembles without errors, but gives the same "Invalid object file" message upon linking. In this case, the source code is incorrect. Notice that the allocation of memory space for the variable FIELD is not within a segment; this is illegal and should be caught by the assembler.

Ted Mirecki is a corporate planner with a master's degree in computer science and 20 years' experience in information processing.

LISTING 1: BUG1.ASM

```
S1      STRUC                   ;DEFINE A STRUCTURE
FIELD   DD      ?               ;THIS CAUSES LINK PROBLEMS
S1      ENDS

DATA    SEGMENT BYTE
VAR     S1<>                    ;INVOKE THE STRUCTURE
DATA    ENDS
        END
```

LISTING 2: BUG2.ASM

```
S1      STRUC                   ;DEFINE A STRUCTURE
FIELD   DW      ?               ;SINGLE WORDS ARE OK
        DW      ?
S1      ENDS

DATA    SEGMENT BYTE
VAR     S1<>                    ;INVOKE THE STRUCTURE
DATA    ENDS
        END
```

LISTING 3: BUG3.ASM

```
FIELD   DW      ?
        DW      ?

DATA    SEGMENT BYTE
VAR     DW      ?
DATA    ENDS
        END
```

TECH NOTEBOOK 39

FRANK G. LETHER

Solving Cubic Equations

A subroutine for solving general cubic polynomial equations for many disciplines

A biologist recently asked me to write a BASIC subroutine to solve cubic polynomial equations, in support of a project to develop a mathematical model of the migration of pesticides through the organs of fish.

The formulas needed to solve such a general cubic polynomial equation were worked out by the Italian algebraist Cardan during the first half of the sixteenth century. Cardan's formulas are considerably more complicated than the familiar formulas most people encounter in high school algebra for solving quadratic equations. However, once programmed in the form of a BASIC subroutine, the application of Cardan's formulas is transparent to the user.

Since the solution of cubic equations is a common task in the applied sciences and engineering, this subroutine could find many other applications. The listing below contains a BASIC program that can be used to calculate the roots of a cubic equation to at least five significant decimal digits. The relative order of the coefficients *a, b,* and *c* for the equation are specified to the user in the runtime prompt issued by lines 125 and 130 of the driver. Some of the arithmetic within the subroutine is done in double precision to minimize the effects of round-off errors. Accordingly, the /D option of the BASIC command should be used to invoke the double-precision, transcendental functions ATN, SQR, and COS. (See the IBM *Basic Manual*, revision 2.0.)

The program can be exercised on all three root cases and tested for correct entry on a system by running the following simple examples:

Case 1: $a = -1, b = -1, c = 1$ with roots $-1, 1, 1$
Case 2: $a = 0, b = 1, c = 0$ with roots $0, i, -i$
Case 3: $a = 1, b = -2, c = 0$ with roots $1, -2, 0$

Frank G. Lether, Ph.D., is a professor of mathematics at the University of Georgia. He is a numerical analyst doing work in applied mathematics. Lether has 20 years of experience in computer science.

LISTING: CUBIC.BAS

```
100 'Test driver program for solving a cubic polynomial equation
110 CLS : SCREEN 0 : WIDTH 80 : KEY OFF : LOCATE 1,1
115 PRINT "Enter coefficients a, b and c of the cubic equation"
120 PRINT
125 PRINT "              3         2"
130 PRINT "             x   +  a x   +  b x  + c  =  0"
135 PRINT
140 INPUT "... enter a   ",A : PRINT
145 INPUT "... enter b   ",B : PRINT
150 INPUT "... enter c   ",C : PRINT
155 GOSUB 1220  'Solve cubic equation using Cardan's formulas
160 IF CASE=1 THEN PRINT "CASE 1 - multiple real roots" :PRINT
165 IF CASE=2 THEN PRINT "CASE 2 - real and complex roots":PRINT
170 IF CASE=3 THEN PRINT "CASE 3 - 3 distinct real roots" :PRINT
175 PRINT "real part of root    imaginary part of root"
180 PRINT "----------------    ---------------------"
185 PRINT USING "######.####          "; X1.RE,X1.IM : PRINT
190 PRINT USING "######.####          "; X2.RE,X2.IM : PRINT
195 PRINT USING "######.####          "; X3.RE,X3.IM : PRINT
200 END
1010 '  SUBROUTINE - solve for the roots of
1015 '              x^3 + a*x^2 + b*x + c = 0
1040 '  This subroutine solves a cubic polynomial equation
1050 '  with real coefficients using Cardan's formulas as
1060 '  described in Uspensky,J.V., Theory of Equations,
1070 '  McGraw-Hill,1948, pp.84-94 .
1090 '  INPUT : A , B , C       Polynomial coefficients (real)
1110 '  OUTPUT: X1.RE , X1.IM   Real and imaginary parts of the
1120 '     X2.RE , X2.IM      three roots of the cubic equation
1130 '     X3.RE , X3.IM
1140 '     CASE               = 1 if multiple real roots
1150 '                        = 2 if one real, two complex roots
1160 '                        = 3 if real unequal roots
1180 '  VARIABLES : EPSLON, PI#, THIRD#, SQRT3# , X#, P#, Q#,
1190 '    HOLD#, A#, B#, HOLD1#, HOLD2#, TAN.PHI#, PHI#, DEG#,
1200 '    ARG1#, ARG2#, ang#, DEL#, TEMP#,
1210 ' initialize constants
1220 EPSLON = .00005 : PI# = 4# * ATN(1#)
1230 THIRD# = 1# / 3# : SQRT3# = SQR(3#)
1240 DEG# = PI# / 180#
1250 ARG1# = 120# * DEG# : ARG2# = 240# * DEG#
1260 '  define real cube root
1270 DEF FN CUBERT#(X#) = SGN(X#)*ABS(X#)^THIRD#
1290 P# = B - THIRD#*A*A              'compute discriminant
1300 Q# = C - THIRD#*A*(B - 2#*A*A / 9#)
1310 DEL# = 4*P#*P#*P# + 27*Q#*Q#
1330 IF ABS(DEL#) = < EPSLON THEN CASE=1   'multiple real roots
1340 IF DEL# > EPSLON THEN CASE = 2    'complex roots
1350 IF DEL# < -EPSLON THEN CASE = 3   'real, unequal roots
1370 ON CASE GOTO 1430,1540,1680       'branch for cases
1400 '  CASE 1 : DEL# = 0                  'multiple real roots
1430 TEMP# = -THIRD#*A : HOLD# = FN CUBERT#(.5*Q#)
1440 X1.RE = TEMP# - 2# * HOLD#
1450 X2.RE = TEMP# + HOLD#
1460 X3.RE = X2.RE
1470 X1.IM = 0 : X2.IM = 0 : X3.IM = 0
1480 RETURN
1510 '  CASE 2 : DEL# > 0                   'complex roots
1540 TEMP# = SQR(DEL# / 108#)
1550 A# = -.5*Q# + TEMP#
1560 B# = -.5*Q# - TEMP#
1570 HOLD1# = FN CUBERT#(A#) : HOLD2# = FN CUBERT#(B#)
1580 X1.RE = -THIRD#*A + HOLD1# + HOLD2# : X1.IM = 0
1590 X2.RE = -THIRD#*A - .5*(HOLD1# + HOLD2#)
1600 X2.IM = .5*SQRT3# * (HOLD1# - HOLD2#)
1610 X3.RE = X2.RE : X3.IM = -X2.IM
1620 RETURN
1650 '  CASE 3 : DEL# < 0                   'real unequal roots
1680 IF ABS(Q#) = < EPSLON THEN PHI# = .5# * PI#:GOTO 1720
1690 TAN.PHI# = -SQR(-DEL#) / (Q#*SQR(27#))
1700 PHI# = ATN(TAN.PHI#)
1710 IF Q# > EPSLON THEN PHI# = PI# + PHI#
1720 TEMP# = 2# * SQR(-THIRD#*P#) : HOLD# = -THIRD#*A
1730 ANG# = THIRD# * PHI#
1740 X1.RE = HOLD# + TEMP# * COS(ANG#) : X1.IM = 0
1750 X2.RE = HOLD# + TEMP# * COS(ANG# + ARG1#) : X2.IM = 0
1760 X3.RE = HOLD# + TEMP# * COS(ANG# + ARG2#) : X3.IM = 0
1770 RETURN
```

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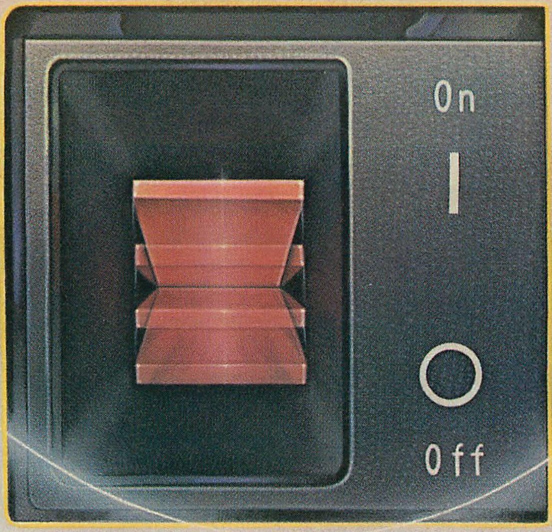


Making Connections

TURN-ON, a phone-activated PC power controller, turns an unattended computer on and off as needed.

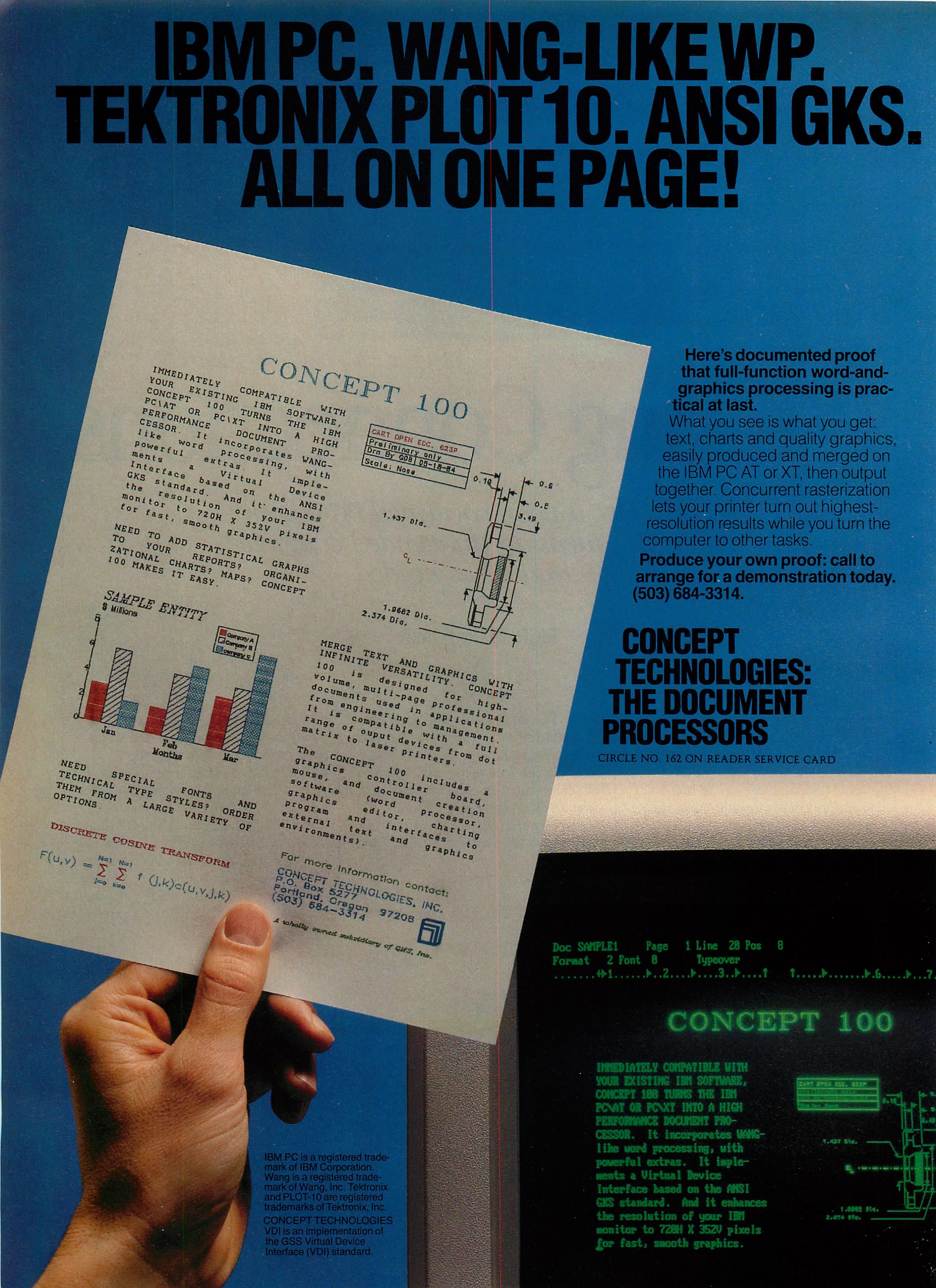
RICHARD M. FOARD

The idea of leaving a PC and modem turned on while its user is away is usually dismissed immediately. It seems like a waste of electricity to leave the computer on 24 hours a day and too much trouble to set up a telecommunications program each time—just in case someone might want to call in to exchange mail or data files.

A new product from Skyland Systems may change the minds of many busy or energy-conscious telecommunicators. The product, an ingenious little box called TURN-ON, sits quietly between the telephone and a turned-off computer system waiting for calls. When the telephone rings, TURN-ON answers and switches the computer on, keeping the system powered up as long as the caller stays on the line. When the caller hangs up, TURN-ON flips the power back off and waits for another call.

But, this little box does even more. It protects the computer from damage by sudden power "spikes," as well as power surges and other abrupt distortions of the A.C. service. Its six grounded AC outlets enable it to replace a conventional power strip, allowing an entire computer system to be turned on and off from a single switch. Unlike ordinary power strips, TURN-ON does not have a master on/off switch. Instead, one of its outlets is designated the *sense receptacle*. Turning on and off whatever device is plugged into the

ILLUSTRATION • ANDY LEVINE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sense receptacle controls the power to everything else. Since most power strips end up resting in a pile of tangled wires on the floor, the sense device approach to master power control can save a lot of reaching and crawling. Turning on the monitor, the printer, or even a desk lamp will automatically power up the rest of the system. Any device that uses five watts or more of power will trigger the sense receptacle when turned on.

Another advantage TURN-ON has over conventional power strips is its automatic staging of power. The device plugged into the outlet designated the *CPU receptacle* is switched on two seconds after the others, allowing peripherals to get a head start on the CPU by performing power-on initialization before the computer comes on-line. (Some users might prefer to plug their external hard-disk drives into this receptacle so that the disk will be turned on only after the computer's signals have stabilized.)

TURN-ON's power capacity is ample for microcomputer systems. The CPU outlet handles 7.5 amps, the sense outlet 3 amps, and the other four carry a combined load of 7.5 amps. The box can handle a total current of 10 amps (1,250 watts) to all devices and is fuse-protected. Even though most power strips these days have small, built-in circuit breakers, TURN-ON disappointingly falls back on an older protection technology. Early builds of TURN-ON were not U.L. approved, but all units being shipped today carry the U.L. label and are fully approved.

Enclosed in a 10-by-5-by-3-inch anodized aluminum box, TURN-ON is a compact and attractive unit. It sports a red pilot light that glows when it is receiving power; the light blinks when a call is received and continues to blink after the call is finished, providing a convenient indication that the computer was used while it was left unattended.

TURN-ON can be left connected to the phone line when the PC is in normal use. When the computer has been turned on locally, incoming calls are detected and cause the pilot light to blink, but they are not answered and the computer is left turned on when the caller hangs up. In addition, an incoming wrong number will not shut the machine down in the middle of a job.

Installation of TURN-ON as a power controller is simply accomplished by plugging the computer, modem, and peripherals into TURN-ON's outlets. The sense receptacle must be occupied; aside from a phone call, the sense receptacle is the only way to bring power up to the other five power outlets. Telephone and modem cords should be plugged into the two modular telephone connectors and, after a little work on the software side, TURN-ON will be ready to use as an unattended bulletin board, electronic mail, or remote file transfer system.

Setting systems software up to get an unattended PC system from a turned-off state into remote control operation is accomplished by using PC-DOS's AUTOEXEC.BAT file to load a telecommunications program, then using the program's facilities to answer the phone and provide service to the caller. With Crosstalk, for example, a system is quickly set up for unattended operation by creating an AUTOEXEC.BAT file that gives the DOS command to invoke Crosstalk, specifying an initial script file

When the telephone rings, TURN-ON answers and switches the computer on, keeping the system powered up as long as the caller stays on the line; then it shuts off.

```
xtalk autoans     (AUTOEXEC.BAT)
```

and creating a Crosstalk script file, autoans, which begins with Crosstalk commands to set the communications parameters and place the modem into answering mode—for example,

```
speed 1200     (Crosstalk script)
mode answer
```

This is the minimum amount of set-up work required to get a system on the air as a Crosstalk file server. Configured this way, a PC responds to a telephone call by powering up, loading Crosstalk, answering the phone, and greeting the caller with Crosstalk's sign-on message. The caller is then able to access Crosstalk's remote command facility to send and receive files.

IMPATIENT MODEMS

Calling a system equipped with TURN-ON can be a little trickier in practice than it sounds in principle. A turned-off PC has a good bit of work to do to get itself ready to communicate and can consume a good bit of time in the process. The PC's power-on self-test can take 50 or 60 seconds, depending on the amount of memory installed. Loading DOS and a communications program takes still more time, especially on floppy-disk-only systems. All this preparation must transpire before the modem answers the phone and raises a carrier signal. It is not unusual for a PC to take a minute and a half to compose itself, and many callers are not that patient.

Modems manufactured by CTS Corporation, for example, by default allow only eight rings before giving up and reporting "no answer" to their controlling software. They can be commanded to wait for as many as 15 rings, but this requires that the host software know how to override the default setting. Even with the modem set to wait through 15 rings, a remote PC with 256KB of memory and floppy disk drives barely beats the timeout. Systems with more RAM simply will not answer the phone in time. Further complicating the situation, call-originating software often imposes its own "soft" time limit on the called system's response time.

TURN-ON's manufacturer recommends a solution to this problem that can be applied by users with modems capable of answering calls on their own. (Most smart modems can be configured to answer a call and establish a carrier signal even though no Data Terminal Ready signal is coming from the computer.) Implementing the solution requires that the modem be plugged into the phone line directly, instead of via TURN-ON, and that a special cable be made up and installed. This cable will carry two of the lines in the modem-to-computer cable to a control plug on TURN-ON. When configured this way, the modem immediately answers incoming calls, detects and responds with carrier, and raises a signal (carrier detect) to TURN-ON's control port, which causes TURN-ON to switch the computer system on. Although it takes more time and trouble to set the system up this way, the arrangement eliminates all timing problems and has the beneficial side effect that wrong numbers will never switch the computer on and off.

This same control port can be used in other, more sophisticated ways. A computer or other device attached via its parallel or serial port to a cable running to TURN-ON's DB25 control port connector can detect whether or not TURN-ON is applying power to the attached equipment and, if it is, whether it was originally turned on by a phone call or by someone turning on the sense device. Through the same port,

TURN-ON can be signaled to turn the computer off and on, or commanded to ignore telephone calls entirely.

Connecting a computer, operating under TURN-ON-mediated power, back to TURN-ON's control port affords communications software substantial flexibility. Using the functions and status signals provided through the control port, software can determine how it was turned on (locally or as a result of an incoming call) and act accordingly. By delivering command signals back to the control port, call-activated software is able to keep its machine powered up after the caller hangs up, or shut the machine's power off in mid-call.

OPTIONAL SOFTWARE

TURN-ON can be purchased with or without a companion $75 communications software package that includes a user file management system, a log-on control and user validation program, and a file transfer system.

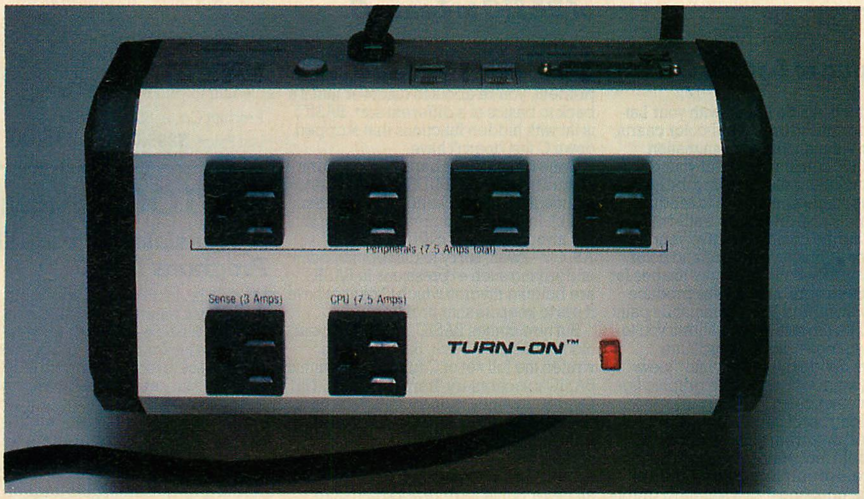
The Skyland software package is oriented toward multiple-user file transfer or bulletin board-style operation, in which many potentially untrustworthy users call and use the unattended computer. Its LOGON program manages a database of user names, passwords, and privileges, and it restricts access to the system using a conventional log-in dialogue. LOGON also records all system activity in a disk file, including unsuccessful attempts to log in.

The file transfer facility, FILETRAN, incorporates an error-checking protocol and allows file-by-file control of user send and receive privileges.

Used together, the Skyland-supplied programs support bulletin board, special-purpose, or general-purpose remote use of the PC by allowing the system operator to set up user names in one of three categories: file transfer, special program, or ctty. Users in the file transfer category are automatically placed under control of the FILETRAN program on the remote computer when they call and can make use of FILETRAN's facilities for sending and receiving unprotected files and querying the directories of the unattended system. When a special program user logs in, a program previously set up by the system operator is automatically executed and placed in communication with the calling user. Ctty users are given full control of the unattended computer by means of the DOS CTTY command.

To take advantage of the TURN-ON package's file transfer capabilities, the calling PC as well as the unattended PC must be running Skyland's FILETRAN program, which uses a communications protocol of Skyland's own invention. Skyland's software license agreement permits a TURN-ON owner to distribute as many copies of the software as he wants, provided that the PC at one end of every conversation is equipped with a TURN-ON device. Prospective TURN-ON users who are not already committed to another communications package will find Skyland's software an attractive option especially if they plan to make their PC available to a wide community of users. Its password protection scheme and ability to attach different file transfer and program execution privileges to different users and files make it well suited for bulletin board or electronic mail applications.

According to the manufacturer, some reported problems with TURN-ON have been caused by certain "100-percent Hayes-compatible" modems that are a little less than 100-percent Hayes-compatible. The Qubie modem, for example, will answer the phone if a ring signal is present while it is initializing itself at power-up—and then immediately drop the line. The Hayes series of modems do not exhibit this behavior. Other modems—particularly the Racal-Vadic Maxwell and Prentice PopCom—also have Hayes-incompatible quirks that interfere with their use in conjunction with TURN-ON.



TURN-ON Is entirely encased in a six-sided aluminum extrusion, and while it lacks mounting holes, it is rugged enough to be placed anywhere without fear of damage.

In my own testing of TURN-ON, using a Hayes Smartmodem 1200, the unit seemed robust and completely reliable and performed as advertised. A test with a CTS Corporation modem caused problems, but because the CTS modem does not claim to be completely Hayes-compatible, neither the modem nor TURN-ON can be faulted.

To individuals and business computer users, TURN-ON offers two kinds of opportunity. It allows those already using PC-based unattended communications to reduce electricity costs and computer wear and tear significantly. At a nickel a kilowatt/hour, TURN-ON pays for itself in power costs alone in just over 30 months by allowing a 300-watt system to operate 8 instead of 24 hours a day. It can increase an organization's productivity, too, by reducing the likelihood that communications attempts will fail because someone left the office in a hurry and forgot to turn the computer or modem on or failed to leave the communications package running.

TURN-ON creates a new opportunity for low volume or off-hours communicators who have previously balked at the idea of leaving their PCs running 24 hours a day. East Coast offices of West Coast companies, for example, can use TURN-ON to stay ready to send and receive files until the close of business, Pacific Standard Time, without running up overtime, electricity, or computer maintenance bills.

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Richard M. Foard is vice president of software development for ROADNET Systems Corporation, a Baltimore-based company.

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- You can move a window on the screen.
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It's a long list of capabilities which make for an extraordinarily powerful product. In fact, Halo is so good that manufacturers of graphics boards and systems are adopting it as a standard graphics language. So it can bridge your application to other systems. CAD-CAM developers, especially, have embraced its device-independent approach for maximal portability. Halo offers a dazzling demonstration that function library architecture will tremendously enhance your firepower.

You'll need an IBM monochrome or color graphics board for our standard version, but other versions now support ten boards and their equivalents. Halo is sold in a one board, one language configuration (special pricing for multiples), but each version now comes with a multitude of I/O drivers for mice and printers.

Tip: Ask us to throw in Dr. Halo for an extra $95. It's a "paint" program written with Halo, far surpasses other pretenders, and will open up realms of creativity. Brilliant beyond belief.

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PMATE
The Programmer's Word Processor

Pmate™ was designed for programmers. We'll wager that you cannot find a programmer who has discovered Pmate and moved on to something else.

Pmate is a full screen editor with ten auxiliary buffers for squirreling away pieces of text until needed. It uses single key commands to move the cursor, or text, or insert or delete, or rescue several thousand characters of deleted text.

It has a format mode for tab setting or wraparound and shaping when it's time to write documentation. Pmate lets you assign chains of commands or strings of text to single keys: a keystroke could set up the entire shell of a new C function, for example.

Pmate has variables, if-then statements, loops. It calculates, and converts decimal to hex to binary and back. You can write compact programs (called "macros") to delete comments, for example, or check syntax, or process long sequences of commands. Macros can alphabetize lists, do row and column math, perform a series of operations on multiple files, even summon other macros.

Put another way, Pmate is a text editor with its own built-in interpretive language. A language you can use to completely customize this text editor to your fancy. Possibly the most artful, ingenious program you have ever seen.

Product Code: S0600 # Our Price: **$175.00**
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BASIC_C
Use Your Knowledge of BASIC to Learn C

If you're getting the message that switching from BASIC to C would be prudent, you're about to discover that it's back to basics of a different sort. BASIC is fat with hidden functions that stripped down C just doesn't have.

Gone are all those handy string manipulators like LEFT$, MID$, STRING$, etc. (although our library offerings add them back). In C, when you reach for even simple invocations like INPUT or PRINT A$,X% — well, sorry to disappoint, but underlying such expressions in BASIC are bulging macros which C cannot have if it is to keep its slim profile.

But now comes BASIC_C and all your old favorites are back. Someone has written the full set of C functions to mimic BASIC's vocabulary, from ABS to WRITE. Over 80 routines to open and close files, "field" file buffers, convert their contents from and to strings (the CV? and MK? series), peek and poke, print using, clear screen, "instr", on error goto. . . they're all there. Some have reworked names and syntax to suit C, but all are written as one-to-one functional equivalents to the familiar features of BASIC. And they are documented one to a page in alphabetical sequence like the Microsoft manual for added familiarity.

So with BASIC_C, when you're thinking INPUT, go ahead. Use it. Or LPRINT or LOCATE or INKEY. But without BASIC_C, you will find that every line of code plunges you back in the C texts to figure out how to write it. Someday you'll want to, but for now, BASIC_C will start you programming quickly at the statement level so that you can concentrate on C's larger concepts.

There's a bonus: an unusually well-written manual with a first rate chapter comparing how BASIC and C go about their tasks. Without question, BASIC_C will ease your transition to C.

Product Code: S0350 # Our Price: **$145.00**
List Price: **$175.00**

BASTOC NEW!
It Translates Your BASIC Programs Into C

You'd like to upgrade C, but what to do with that warehouse of BASIC routines you've carefully polished over the years? And how to face converting your famous Leviathan accounting system from BASIC, much less your Labyrinth file management package?

With BASTOC,™ a translator which takes in BASIC source code and emits pure Kernighan & Ritchie C. BASTOC understands Microsoft Extended BASIC, both interpreter and compiler forms of CBASIC (except for dynamic dimensioning and common), and can be tailored to understand other dialects. It will optionally convert your program into a single monolithic C function or will decompose it into separate functions, one for each GOSUB label.

Strings are dynamically allocated in the target program, ridding your application of BASIC's catatonic halts for garbage collection. BASTOC will try to create structure of even the most convoluted BASIC code, and writes any indigestible statement into the C output as a comment plus explanation. Also, you optionally can tell BASTOC to insert BASIC source lines into the C target as comments.

Source code of several modules of the translator and library are provided so you can tailor BASTOC to your environment if needed. And source of the entire product is for sale.

Product Code: S0370# Our Price: **$280.00**
List Price: **$350.00**

TO C OR NOT TO C IS NO LONGER THE QUESTION

BTRIEVE

Is a Pro Like You Still Doing the Filing?

If your programming still gets anywhere near the files, here's our guarantee: Nothing will increase your productivity faster than handing the filing job to a sophisticated file manager.

Btrieve™ is the best we have seen. It takes complete charge of all file indexing, reading, writing, insertion and deletion. It builds 22 commands right into the language you use in the form of functions you call to tell Btrieve what to do. The commands create, open, and close files; delete and insert records, recapturing vacated space; find records which exactly or most nearly match keys; walk files by ascending or descending key.

Btrieve's foundation is a balanced-tree indexing scheme, conceded to be the fastest search technique devised (it will find any key in a million-plus item index in four or less accesses).

Btrieve comes with interfaces to C, Pascal, BASIC, and COBOL, and the manual gives you working sample programs which demonstrate every command in all four languages. The kind of presentation which led *PC World* to exclaim "for those of us who have endured poorly written and inadequate manuals, this one is a pleasure to read."

Btrieve has mainframe specifications! A single file may have up to 24 indexes. Segments of keys may be indexed. Each index can independently accept or block duplicate keys. A record length can be up to 4090 characters; an index length 255 characters. A file may be 4 billion bytes. It can even extend a file across two drives — even two hard disks!

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List Price: **$245.00** **$199.00**

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C's structured approach encourages development of tight, fail-safe functions which can be counted on to return reliable results every time. Its local variables are unknown outside of functions which safeguard against accidents elsewhere. C offers powerful nested expressions which produce elegant, concise code. That's why C has become the language of choice among professionals.

Lattice C™ is the Number One C compiler. Peter Norton in *PC Magazine* (1/8/85) says, "best for systems programming... tight code... total control of what's going on... noticeably better than any of its competitors." After reviewing nine compilers for the PC, the *PC Tech Journal* unequivocally declared Lattice C "best for software development... it compiles fast and produces fast programs".

Lattice C runs on virtually any computer using an 8088 or 8086 chip, and generates code which optimizes use of the 8087 chip, if present. Create your source files with any word processor or text editor like our Pmate or ES/P for C, and Lattice C will compile them into Intel 8086 object module format for linking to other modules by DOS's Link or our Plink86.

Lattice C offers a choice of four memory models between 64K and RAM capacity for program and data to allow the program designer to choose the right combination of small memory efficiency and large memory addressability for an application.

Lattice C is a full implementation of Kernighan and Ritchie (K&R), not a subset, with some extra features, eg., variable names up to 39 characters, and nested comments.

The compiler comes with a library of I/O routines which implement under MS™-DOS most of the Unix-compatible standards described by K&R, and then goes beyond. It has a fulsome set of transcendental and Unix math functions K&R didn't think to mention, and some of Unix's most useful options such as "fork", which can pull a second program into memory without disturbing the first, branch to it, and return.

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Product Code: S0400 #* Our Price:
List Price: **$295.00** **$235.00**

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PLINK86

Size Unlimited with This Overlay Linker

Software is becoming ever more sophisticated, which means more complex programs requiring large chunks of memory. But if you use extra memory, you count on users to have expanded RAM, and forego sales to those who do not.

Plink86™ is the answer. It shoe-horns large programs into small memory. First, Plink86 acts as an alternative to DOS' Link. C encourages design of separately compiled object modules in the Microsoft relocatable format. Plink86 pulls modules together into single compiled programs. But Plink86's overlay power is what has gained it a reputation as a miracle worker. It binds into the compiled program its overlay manager which knows how to swap modules of your large linked program between disk and memory, so that each can temporarily occupy the same memory space.

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Plink86 can even sub-divide its linked output into multiple files for programs which must span more than one disk. And it produces a symbol map for debugging with Pfix86 Plus.

PC Tech Journal calls it "the premier linker and overlay loader that's taking over at many of the programming shops around the country."

Product Code: S0500 # Our Price:
List Price: **$395.00** **$315.00**

RUN/C REVOLUTIONARY!

A C Interpreter at Last — And it Works like BASIC!

C is contemplative, elegant. But even elitists yearn (silently) for the simpler days of throwing together code with the instant interaction of an interpreter.

The good old days are here again. We have not just a C interpreter, but one that acts like BASIC! Use RUN/C's in-line editor to create a program. RUN it, just like BASIC. If it stumbles, just LIST it, EDIT it, add lines, delete lines, RUN it again, fix it again. The simple luxury of break key interrupt is restored, and RUN/C™ even has TRON, TRACE, and a profiler which reports the number of times each program line is executed.

RUN/C's "editor" command will save a program and automatically hand it to your favorite editor for further work. Or you can use its "shell" command to summon your compiler from *within* RUN/C.

For the professional, RUN/C is ideal for rapid program development. Put up code at high speed, tinker and re-arrange, throw in test printouts, bang away at tight little sections until they're bullet proof — *then* hand them to the compiler.

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Your disk supplies a separate source code file demonstrating each of RUN/C's library functions, with a manual to match. In fact, if you are new to C, this product doubles as a superb tutorial! (Requires 256K, DOS 2.x).

Product Code: S0900 # Our Price:
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List Price: Code		Our Price:
Pfix86 S0550	#**$195.00**	**$155.00**
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CIRCLE NO. 171 ON READER SERVICE CARD

Reflections of UNIX

The market for PC operating systems has added six important UNIX contenders.

AUGIE HANSEN

Although PC-DOS is several long strides ahead of its nearest microcomputer competitors in the operating system arena, it is still many laps behind the multitasking, multiuser systems, typified by UNIX, in terms of flexibility, convenience, and overall capability. For those who are accustomed to using UNIX, DEC's VMS, Data General's AOS, or other larger time-sharing operating systems, PC-DOS can be confining and often frustrating to use. A PC-DOS-equipped computer spends most of its time doing nothing very fast—usually it is marking time in the gaps between the user's keystrokes.

Several companies, including IBM, sell UNIX systems for the PC or PC/XT. Some are stripped-down versions of UNIX that have been tailored to the PC equipped with floppy disks only; most, however, require an XT and a lot of memory. A survey of the PC and XT UNIX marketplace reveals six important contenders. Three are licensed UNIX AT&T source code descendants: PC/IX, VENIX/86, and XENIX; the others were written from scratch to mimic UNIX behavior: COHERENT, QNX, and uNETix. Members of the latter group vary in the accuracy of their impersonations, but generally cost less than the licensed versions (see table 1).

AT&T has exclusive rights to the UNIX name, but most companies making UNIX-like systems try very hard to get at least the "IX" part of the name into their products' monikers.

All of these UNIX and UNIX-like operating systems can fill in the idle gaps between keystrokes by letting a user do more than one task at a time, and in most cases, by permitting more than one user at a time to access and use the computer's resources.

PC-DOS users have had a glimpse at a small subset of UNIX features. Each successive version of DOS has added something from UNIX: the hierarchical file system; the **sort** and **find** (like **grep**) commands; redirection; and piping to name a few. Although new to the commercial market, and particularly to microcomputers, UNIX has been in daily use for more than a decade at AT&T and on university campuses around the world. Some 8-bit adaptations (Cromemco's CROMIX, for example) have been in use for about five years. But the real impetus for UNIX growth in the microcomputer market has been the 16- and 32-bit microcomputer sales boom of the past three years.

The UNIX system is written almost entirely in a high-level language (C), so it can be moved readily, although not painlessly, to vastly different host environments. The porting process involves rewriting the machine-dependent parts of the operating system kernel and recompiling the system and applications software in the new environment.

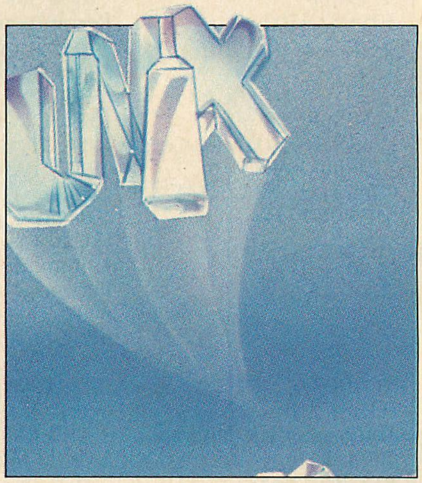
The PC versions of UNIX are modified to varying degrees from the mainstream versions because of limitations of the underlying hardware and due to the philosophies of the companies doing the porting or emulation tasks.

UNIX FEATURES

Aside from the relatively high degree of portability of the operating system itself, a number of other characteristics of UNIX make it attractive to a growing user population. It is a multitasking, multiuser system that greatly improves the CPU utilization and, therefore, the overall throughput of a computer by permitting many tasks to be performed concurrently. Both foreground and background processing are available to users. Redirection of standard input, standard output, and error streams is supported by the user shell that is the interface between users and the operating system. The elegant piping capability facilitates the use of existing tools in custom mix-and-match combinations and encourages the creation of new tools to meet special needs.

UNIX provides a measure of security through its log-in/password mechanism and by file access restrictions. Some installations use multiple levels of password protection (external and internal) to prevent unwarranted access. Each file and directory can be restricted at the user, group, and other levels for read, write, and execute access.

File systems are hierarchical and resemble the root system of a tree. The root directory of the UNIX file system is called / and under it can be any number of subdirectories nested to any depth. File systems may be mounted and dismounted easily. Separate file systems for different parts of a system (system space, user space, etc.) offer a degree of isolation that keeps one file system from corrupting another while permitting ready access and data exchange across file systems. The user



does not need to know what device a particular file system is mounted on. The system maintains a table of mounted file systems and lets the user find files and directories by path names similar to those used under PC-DOS.

A command interpreter called a *shell* provides users with access to system resources. The shell is also a programming language, having the necessary sequencing, looping, and decision-making structures common to all viable computer languages. Several shells are available to UNIX users. The AT&T standard Bourne shell (**sh**) and a restricted version of it (**rsh**) are available on most systems. The Berkeley C shell (**csh**), which has a syntax that is more consistent with the C language and which is especially popular with programmers, is also available on many systems.

In addition, some suppliers are providing visual shells to simplify interactions with UNIX for users whose needs are relatively predictable and limited in scope. Candidates for such menu-driven interfaces are general office workers, word processing specialists, management, or others who have no need to understand programming. Such shells will help to negate the perception of UNIX as being too complex.

UNIX does have a frightfully large set of standard commands, many of which are listed in table 2. A small set of the commands (**cd**, **pwd**, **cat**, etc.) evolved quickly in the early days of UNIX. Others just grew up out of necessity during the incredibly long gestation period that followed while UNIX was being tinkered with and "commercialized." The resulting inconsistent syntax among commands, seen as a flaw of UNIX, is a result of this relatively unfettered development of the system by many individuals in disparate locations and circumstances. At the same time, that kind of development has led to some of the finest applications and support tools in the business.

Table 3 lists the primary UNIX system administration and maintenance commands. System accounting data can fill up a disk on a busy system in the blink of an eye, so most of the microcomputer versions of UNIX disable the accounting software by default. Other commands are used to create, maintain, mount and dismount file systems, back up and restore disk files, and troubleshoot system problems. The **/etc/cron** command triggers events that are scheduled in a file named /usr/lib/crontab (its location may be different on some systems). Events may be added to the crontab file by editing it to instruct UNIX to do tasks at predefined dates and times. **Cron** also runs the **sync**, or **update**, command frequently (usually once a minute) to keep essential file system data up to date on disk. That happens even if no crontab file exists.

A primary use of UNIX is the preparation and management of documents of every description. Table 4 summarizes the major commands used for text processing. Unlike most of the word processors for PC-DOS, which use a single program for editing and on-screen formatting, UNIX uses separate editing and processing steps. The line and screen editors are treated as part of the basic set of system commands because they are primary tools for the manipulation of text in a wide range of applications—from creating mail items to preparing program source files.

The major disadvantage of this approach is a lack of realtime feedback on the appearance of a document. The user must process a text file, which often looks more like a program source file than a document, to see what will actually be printed. The advantage to this method is that a single source file can be produced in a variety of output formats simply by changing the formatter parameters, usually through a set of macro definitions in an optional formatting package. Source files also consist of only standard printable ASCII characters, making them easy to transmit through simple networks.

The primary text processing programs are **nroff** for printing terminal output and **troff** for typesetters. Several preprocessors are used to handle equations (**eqn** and **neqn**) and tables (**tbl**) merged with normal text. Other preprocessors may be used to handle graphics in what is essentially a bit-mapped mode if suitable hardware (a laser printer) is available.

Other commands in this set automate testing of documents for style, readability, spelling, and typographical errors. Some filters are provided to permit text processor output to drive printers with limited capabilities. **Col**, for example, lets line printers that cannot do reverse linefeeds handle text that contains them by buffering the output and simulating the reverse motion through the use of backspacing and carriage returns. A permuted index (sometimes called KWIK for key word in context) may be prepared automatically by **ptx**. **Deroff** strips formatting commands out of document source files so the files may be processed by other programs that would produce erroneous results if the commands were left in. For example, the word count command, **wc**, would report higher numbers than it should for character, word, and line counts if the source file were not **deroff**ed beforehand.

Another major use of UNIX is development of software. Table 5 lists the primary programs in this set. The range of programming tools spans preprocessors, compilers and interpreters, assemblers, linkers, and various testing tools. Of course, the primary language tool is the C compiler, but UNIX has support for FORTRAN (**f77** and **ratfor**), SNOBOL (**sno**), and even BASIC on some systems. Many installations also have the Berkeley Pascal interpreter and compiler available. **Lint**, the C source program checker, debuggers such as **adb** (and sometimes **sdb**), and assorted tools, such as **cref**, **time**, and **ctags**, aid programmers in the debugging and maintenance phases of their work.

In addition, UNIX has a full set of management tools to assist users in the software engineering aspects of major development projects. The basic management tool is **make**, which uses **makefiles** to control the process of building programs from a variety of sources. SCCS (source code control system) takes the management of a software project further by providing a means of storing multiple versions and releases of a product in a convenient, easily audited way. Multiple versions of a source file are managed by maintaining a base file along with delta files that can be used to recreate any version of the source while conserving disk space. Some systems have RCS (revision control system), a newer alternative to SCCS that was developed outside of AT&T/Bell Laboratories. It reportedly has a more friendly user interface than SCCS.

TABLE 1: *UNIX Product Summary*

PRODUCT	MINIMUM CONFIGURATION	COMPONENTS	PRICE
LICENSED VERSIONS:			
PC/IX 1.0 IBM Entry Systems Division P.O. Box 1328 Boca Raton, FL 33433 305/982-4700	IBM PC/XT with 256KB RAM 1 ds/dd floppy disk drive Minimum partition 3MB Recommended: Minimum partition 7MB	Bundled	$ 900
VENIX/86 2.0 UniSource Software Corp. 71 Bent Street Cambridge, MA 02141 617/491-1264	IBM PC (with a hard disk), PC/XT, or compatible 192KB RAM (for C compiler) 1 ds/dd floppy disk drive Hard disk Minimum partition 3.5MB Recommended: 8087 coprocessor Additional RAM	Single-user Mulituser Final Word Leverage ViewComp Office Menu Tool	800 1,000 395 395 395 125
XENIX 3.0, release 1.1 The Santa Cruz Operation 500 Chestnut Street P.O. Box 1900 Santa Cruz, CA 95061 408/425-7222	IBM PC (with a hard disk), PC/XT, or compatible 256KB RAM 1 ds/dd floppy disk drive 10MB or larger hard disk Minimum partition 5.5MB Recommended: 8087 coprocessor 384KB-512KB RAM	XENIX OS Development Sys. Text Processing System INFORMIX Lyrix Word Processor Multiplan XENIX OS Development System, and Text Processing System	595 595 395 795 595 495 1,350

Additional components of the development set include screen management tools such as **curses**, **termcap**, and **terminfo**. These functions and databases are used heavily in programs that must manipulate the screen of a video console or terminal directly.

Program libraries are an important part of this set, too. Prepackaged routines for processing strings, doing mathematical operations, and handling graphics interfaces are provided. C is a compact language that does not have any built-in I/O, so standard libraries that are portable across many machines and operating systems are essential.

UNIX provides several layers of communications support. Because many users access a system via remote terminals, either dedicated lines or dial-up ports or a mix of the two are primary components of a UNIX system. When feasible, direct connections are best because the transmission rate can be set to the maximum allowed by the host's serial ports and the terminals. However, many more users are often assigned to a system than will actually be using it at any given time, so a balance must be struck between dedicated ports and dial-ups that best serves the needs of the user population.

For remote access among geographically dispersed systems, **uucp** (unix-to-unix copy) is used, along with related programs in the family. **Uucp** copies source files to destination files, where the source and destination may be on the same system or on systems that are far apart. Electronic mail and news distributions depend on **uucp**. A loosely connected network of hundreds of UNIX sites covering much of the free world exchange news, program source code, gossip, and electronic graffiti on a daily basis. The **uux** command (unix-to-unix execution) can access a remote system, run commands on it, and send

PRODUCT	MINIMUM CONFIGURATION	COMPONENTS	PRICE
LOOK-ALIKES:			
COHERENT 2.3.35 Mark Williams Company 1430 West Wrightwood Avenue Chicago, IL 60614 312/472-6659	IBM PC (with a hard disk) PC/XT or compatible 256KB RAM 1 ds/dd floppy disk drive 5MB or larger hard disk Minimum partition 2.5MB	Bundled	$500
QNX 1.2 Quantum Software Systems P.O. Box 5318, Station "F" Ottawa, Ontario, Canada K2C 3H5 613/726-1893	IBM PC or compatible 128KB RAM 2 ds/dd floppy disk drives Recommended: 256KB RAM Hard disk Minimum partition 750KB	QNX Kernel Utility/Ed C Compiler/Asm QNX Development System BASIC Compiler Pascal Compiler	225 225 300 650 300 300
uNETix SFS 2.0 Lantech Systems, Inc. 9635 Wendell Road Dallas, TX 75243 214/340-4932	IBM PC or compatible 320 RAM for DOS Emulator 2 ds/dd floppy disk drives Recommended: 512KB RAM Hard disk Minimum partition 1MB	Base System Integration Facility Lattice C Compiler Window Management PowerLink 100 Vi Text Editor	50 100 200 50 150 100

Pricing information and hardware requirements are given for the three licensed UNIX systems and three UNIX look-alikes that were surveyed in this article. Although QNX, by Quantum, is not really UNIX-like, it has some UNIX features.

output to the requesting system or any other accessible system. For security reasons, each system may be set up to reject some or all requests from **uux**.

Another communications program, **cu**, can call UNIX systems and manage interactive sessions, including file transfers, and execution of UNIX commands on either the local or remote system.

UNIX has its critics. So does AT&T for the way it has handled UNIX in the marketplace. The company is often accused of being too slow to react to perceived customer needs. Some complain that UNIX has grown too big and complicated; long ago the system outgrew the stage at which its users could reread the entire system documentation over a weekend to refresh their memories. UNIX is infamous for its number of commands, often obscurely named, and numerous options.

The most notorious UNIX critic is Don Norman, director of the program in cognitive science at the University of California at San Diego, who wrote an internal memorandum at UCSD that eventually became an article called "The Trouble with UNIX" in *Datamation* (November 1981). In it, Dr. Norman lambastes the user interface, saying that "UNIX is a disaster for the casual user." Other critics of the system add to the list of complaints, although most, including Dr. Norman, continue to use UNIX for lack of a better alternative.

Inconsistent command syntax has been a frequent complaint about UNIX. Compounding the problem that it causes is a general lack of mnemonic names. Most command names are cryptic, a few misleading, and others just plain out in left field. The pattern scanning and processing command, for example, is called **awk** (the first letters of the last names of the program's creators, Aho, Weinberger, and Kernighan) instead of a more logical and useful word, such as **patscan**.

One potential disaster for any UNIX user, from novice to experienced, is the unintentional misuse of the remove command, **rm**, with wildcard file specifications. A simple **rm *.o** (the * means any matching string of characters) will remove a group of files from a directory. Typing **rm * .o** (with an extra space) is an easy error to make, but an extremely costly one—it results in *all* the files in the current directory being silently deleted, followed by an error message, "rm: .o non-existent".

In self-defense, many UNIX users have created work-arounds to avoid this problem. Typically a private version of the **rm** command is created and put in a directory that is searched before the **/bin** command directory. The private **rm** command alters the behavior of **rm** to make it require confirmation, or it simply moves the deleted files to a temporary directory, giving the user a means to recover in the event of an error. One recommended change to the **rm** command causes it to be more verbose, prompting for confirmation by default. This feature can be disabled by a new option flag, **-s** for silent, so **rm** could be used in pipeline commands and shell scripts in the usual manner. Such a change would, unfortunately, break a lot of existing shell scripts.

Another often heard complaint concerns the unwanted loss of existing files with the copy (**cp**) and move (**mv**) commands. Both will silently overwrite a file if it already exists. For example, typing **cp filea fileb** would destroy the contents of **fileb**, if the file existed, and would copy the contents of **filea** into **fileb**. UNIX does nothing to warn of the existence of **fileb**. Berkeley UNIX solves this problem with a **noclobber** variable in the user's environment that requires a special assertion before overwriting of a file takes place.

UNIX System III provides no record and file locking features, so it is possible for two or more users to modify the same file or record simultaneously. None of the users is warned of the potential conflict, and no attempt is made to prevent multiple, simultaneous access of the same items. When users are confined to their own directories and files, such conflicts do not occur, but in database applications, for example, such collisions can have dreadful consequences. Berkeley UNIX uses a file system design that includes file locking mechanisms. XENIX, the Santa Cruz Operation's UNIX implementation, uses file locking that gives a controlling process complete access and the ability to block access from any other process to all or any portion of the locked file.

XENIX also uses semaphores to control access to system resources. A semaphore is a regular file entry in the file system, but the file contains no data and it can be accessed by only one process at a time. Processes competing for

TABLE 2: *UNIX Command Summary*

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
at	–	y	y	y	–	–
awk	y	y	y	y	–	–
banner	y	–	y	y	–	–
basename, dirname	y	y	y	y	–	y
bc	y	y	y	y	–	–
bdiff	y	–	y	–	–	–
bfs	y	–	y	–	–	–
cal	y	y	y	y	–	–
calendar	y	y	y	–	–	–
cat	y	y	y	y	y	y
cb	y	y	–	–	–	–
cd	y	y	y	y	y	y
chmod	y	y	y	y	chattr	y
chown, chgrp	y	y	y	y	–	–
cmp	y	y	y	y	–	y
comm	y	y	y	y	–	–
cp, ln, mv	y	y	y	y	copy	y
cpio	y	–	y	–	–	y
crypt	–	–	y	y	–	–
csplit	y	–	y	–	–	–
cu	connect	y	y	–	talk	–
date	y	y	y	y	y	y
dc	y	y	y	y	–	–
dd	y	y	y	y	–	–
df	y	y	y	y	–	y
diff	y	y	y	y	y	–
diff3	y	–	y	y	–	–
diffmk	y	–	–	–	–	–
dtree[1]	–	y	–	–	files	–
du	y	y	y	y	–	y
echo	y	y	y	y	type	y
ed	y	y	y	y	led	y
env	y	–	y	–	–	–

y = command supported
– = command not available
name = quasi-equivalent function provided by this command

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
ex[1,2]	–	y	y	–	–	–
expr	y	y	y	y	–	–
factor	y	–	–	–	–	–
file	y	y	y	y	–	y
find	y	y	y	y	ws	y
fortune[1]	–	–	–	y	–	–
getopt	y	–	y	–	–	–
graph	y	y	–	–	–	–
grep, egrep, fgrep	y	y	y	y	locate	y
gutil	–	–	–	–	–	–
help	y	–	–	y	expl	–
hp	y	–	–	–	–	–
id	y	–	y	–	–	–
join	y	y	y	y	–	–
kill	y	y	y	y	y	y
learn	–	–	–	y	–	–
line	y	–	y	–	–	–
login	y	y	y	y	–	–
logname	y	–	y	–	–	–
look	–	y	y	y	–	–
lpr	print	lp	y	y	spool	y
ls	y	y	y	y	y	y
mail	y	y	y	y	–	–
man	y[3]	–	–	y	–	–
mesg	y	y	y	y	–	–
mkdir	y	y	y	y	y	y
more[1]	–	y	y	–	–	y
newgrp	y	y	y	y	–	–
news	y	–	–	–	–	–
nice	y	y	y	–	–	y
nl	y	–	y	–	–	–
nohup	y	–	y	–	–	–
od	y	y	y	y	dump	y
pack, pcat, unpack	y	–	y	–	–	–

[1]Berkeley UNIX command
[2]AT&T UNIX System V command
[3]Manual facility enabled but no manual pages stored on disk
[4]The QNX shell has a limited scope and a unique syntax.
[5]The uNETix shell is a minimal shell subset—it has no logic or looping capabilities, etc.

the same resource—a port or a data file, for instance—must wait for the currently controlling process to give up control. Standard library functions are provided for the C compiler to implement these capabilities in programs.

Because of a fundamental "fairness doctrine" built into AT&T's production UNIX, the system has no realtime capability, leading to more complaints about UNIX. The scheduler tries to parcel out the limited CPU resource to all requesting processes in an evenhanded manner. Processes that are time-critical cannot be guaranteed sufficiently frequent access to the CPU. In scientific and engineering applications, realtime support is essential, so UNIX has been modified in many ways to provide it.

Within AT&T are numerous modified UNIX systems and derivatives that are used in realtime applications, such as those found in telephone switching systems. Company officials in charge of UNIX development freely admit, however, that they do not fully understand realtime needs and state that UNIX and realtime probably never will be synonymous. Current versions of AT&T UNIX (System III and System V) are sold as general purpose systems that make no pretense at having realtime capabilities.

PC UNIX VERSIONS

Table 1 contains information about pricing and hardware requirements for

TABLE 2: *continued*

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
passwd	y	y	y	y	–	–
pr	y	y	y	y	list	y
ps	y	y	y	y	task	y
pwd	y	y	y	y	y	y
rm	y	y	y	y	frel	y
rmail	y	–	–	–	–	–
rmdir	y	y	y	y	drel	y
sdiff	y	–	y	–	–	–
sed	y	y	y	y	–	–
sh	y	y	y	y	y[4]	y
sleep	y	y	y	y	–	y
sort	y	y	y	y	y	–
split	y	y	y	y	y	y
stty	y	y	y	y	y	y
su	y	y	y	y	–	–
sum	y	y	y	y	–	y
tabs	y	–	–	–	–	–
tail	y	y	y	y	–	–
tc	y	–	–	–	–	–
tee	y	y	y	y	–	y
test	y	y	y	y	–	–
touch	–	y	y	y	–	–

y = command supported
– = command not available
name = quasi-equivalent function provided by this command

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
tr	y	y	y	y	xlat	–
true, false	y	y	y	y	–	–
tty	y	y	y	y	–	–
umask	y	–	y	y	–	y
uname	y	–	y	–	–	y
uniq	y	y	y	y	–	–
units	y	–	y	y	–	–
uucp, uulog, uuname	y	y	y	–	–	–
uustat	y	–	–	–	–	–
uuto, uupick	y	–	–	–	–	–
uux	y	y	y	–	–	–
vi[1,2]	–	y	y	–	–	y
wait	y	y	y	y	–	y
wall	–	y	y	y	apb	–
wc	y	y	y	y	–	y
what[1]	–	–	y	–	–	–
who	y	y	y	y	y	–
write	y	y	y	y	–	–
xargs	y	–	y	–	–	–
yes[1]	–	–	y	y	–	–

[1]Berkeley UNIX command
[2]AT&T UNIX System V command
[3]Manual facility enabled but no manual pages stored on disk
[4]The QNX shell has a limited scope and a unique syntax.
[5]The uNETix shell is a minimal shell subset—it has no logic or looping capabilities, etc.

This table lists commands that are part of the main UNIX System III package, excluding those associated specifically with text processing and program development. Clearly, some systems are more faithful to UNIX than others.

each of the products surveyed in this article. The cost of each system is given for both bundled and unbundled configurations where applicable. AT&T traditionally has sold UNIX as a bundled system, but it, too, is moving toward unbundling some elements of the system to effect a more attractive entry price for the basic system.

The minimum and recommended hardware configurations shown in table 1 define another part of the cost of switching to UNIX. If the necessary hardware is not already on hand, this can be a substantial component of the total system acquisition cost. Of course, the ability to use one computer with several inexpensive terminals can easily bring the per-user cost to an acceptable level when compared to the number of stand-alone systems needed to establish an equivalent configuration.

The accompanying tables do not cover every available UNIX command. They are comprehensive enough, however, to show how well each of the PC UNIX systems mimics UNIX behavior. AT&T UNIX System III is used as a basis of comparison throughout this survey, although some of the products were modeled after an earlier AT&T UNIX, version 7. Commands taken from Berkeley UNIX are included where appropriate. None of the systems tested uses the Berkeley file system and kernel modifications, but several infuse many of the popular Berkeley utility programs.

PC/IX

PC/IX, a product that is sold under the IBM label, was ported to the 8088 from AT&T System III source by Interactive Systems, an IBM vendor of choice for mainframe systems software. This single-user UNIX derivative seems to be a solid, trouble-free implementation of UNIX. It has none of the Berkeley extensions that are provided with some of the other products, but it is faithful to UNIX in every respect.

Interactive Systems offers the **INed** full-screen editor instead of the **vi** editor. **INed** has an unnecessarily complex command structure, awkward cursor movement (no forward and back one-word-at-a-time, for example), and a mystifying line-insert capability. Although the **vi** editor also is complex, it has a more consistent user interface and more predictable behavior

PC/IX has modules for program development and text processing. They may be installed if needed, or their disk file allocations may be held for user work space. The C compiler supports the small model only (64KB text and data), which is one of the reasons **vi**, a very large program, is not supported. Another reason may involve the licensing of PC/IX as a single-user system. **INed** has been designed to work directly with the PC display and cannot be

TABLE 3: *System Administration Commands*

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
acct[1]	y	ac[2]	y	y	–	–
(add user function)	adduser	–	mkuser	newusr	–	–
config	y	–	y	–	–	–
crash	y	–	–	–	–	–
cron	y	y	y	y	–	y
devnm	y	–	y	–	–	–
dump	y	y	y	y	back-up	back-up
fsck	y	fcheck	y	check	chk fsys	y
fsdb	y	–	–	–	–	–
mkfs	y	y	y	y	–	y
mount	y	y	y	y	y	y
ncheck	y	y	y	y	–	–
restor	restore	y	y	y	back-up	restore
(remove user)	–	–	rmuser	–	–	–
shutdown	y	–	y	–	–	QUIT
sync	y	y	y	y	–	y
tar	–	y	y	y	–	y
umount	un-mount	y	y	y	–	y
uuclean	y	–	y	–	–	–

y = command supported
– = command not available
name = quasi-equivalent function provided by this command

[1]The accounting functions are performed by a set of related commands. System III accounting software is emulated closely by PC/IX, XENIX, and COHERENT. Accounting is disabled by default on all systems.
[2]VENIX uses a simplified form of login accounting on a per-user basis.

Commands used to administer and maintain a typical UNIX system are usually reserved for authorized personnel, although some are available to the general user population.

TABLE 4: *Text Processing Commands*

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
checkeq	y	y	eqncheck	–		
col	y	y	y	y	–	–
cw	y	–	y	–	–	–
checkcw	y	–	cwcheck	–	–	–
diction[1]	–	–	y	–	–	–
deroff	y	y	y	y	–	–
eqn	y	–	y	–	–	–
explain[1]	–	–	y	–	–	–
hyphen	y	–	y	–	–	–
mm, checkmm	y	–	y	–	–	–
mmt, mant, mt	y	–	y	–	–	–
neqn	y	y	y	–	–	–
nroff	y	y	y	y	–	–
ptx	y	y	y	–	–	–
soelim[1]	–	–	y	–	–	–
spell, spellin, spellout	y	y	y	spell	–	–
style[1]	–	–	y	–	–	–
tbl	y	y	y	–	–	–
troff	y	–	y	–	–	–

y = command supported
– = command not available
name = quasi-equivalent function provided by this command

[1]SCO credits the University of California/Berkeley for these programs.
[2]QNX has its own text processor called doc that is not compatible with any UNIX text processing tools. uNETix supports text processing via its DOS emulator using available DOS editors and word processors in addition to text editing with the optional vi editor.

This table lists commands that are used to process text files. Such files may be created or modified using one of the line or screen editors that are listed in table 2.

used over a tty connection, although the use of dial-up ports is supported.

PC/IX includes no compilers for FORTRAN, Pascal, or BASIC. The compiler/interpreter **bs**, which is a blending of BASIC and SNOBOL with a C-like syntax, and a SNOBOL interpreter, **sno**, are included in the program development package. The package also contains all of the development support programs, such as **make**, the SCCS utilities, **lint**, and others that ease the burdens on programmers and software engineers in creating, testing, and maintaining programs.

The user interface is the standard Bourne shell—no others are offered. All of the standard UNIX commands worked just as they should. A new command, **li**, does the same job as **ls**, the directory lister, but produces a columnar output, which is more useful on video displays than the linear presentation of **ls**. The help command is included, but the production version of PC/IX has no help file entries in order to save disk space. Users can create their own help files if they wish.

For communications, PC/IX uses a program called **connect** instead of the UNIX **cu** program. It supports a Hayes auto-dialer and can be configured for other intelligent modems as well. Some bugs related to the serial ports have been reported—resulting in a locked-up system and a reboot.

Curses and the **termcap** database are available in full-screen applications. The **/etc/termcap** file appears to be current in its coverage of terminal types. Also, IBM has provided a PC-DOS connection at the disk file read/write level only, but that makes it possible to transfer program source files and standard text and data files between environments. No DOS emulation or cross-development features are included.

IBM's documentation, which is dressed to kill in pin-striped binders, is nicely produced from the original AT&T memos and manuals. Additional documents written by Interactive Systems cover the **INed** editor, **connect**, and other non-UNIX features.

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TABLE 5: *Program Development Commands*

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
adb	y	y	y	db	–	–
ar	y	y	y	y	–	y
as	y	y	y	y	asm	y
bs	y	basic	–	–	cb	–
cb	y	y	y	–	–	–
cc	y	y	y	y	y	y[2]
cref	y	–	y	–	–	–
ctags	–	–	y	–	–	–
(DOS cross-linker)	–	–	dosld	–	–	–
f77	–	–	–	–	–	–
hdr	–	–	y	–	–	–
ld	y	y	y	y	link	lk+ld
lex	y	y	y	y	–	–
lint	y	y	y	–	–	–
lorder	y	y	y	–	–	–
m4	y	y	y	y	–	–
make	y	y	y	y	–	–
mkstr[1]	–	–	y	–	–	–

y = command supported
– = command not available
name = quasi-equivalent function provided by this command

UNIX SYSTEM III COMMAND (except as noted)	PC/IX	VENIX/86	XENIX	COHERENT	QNX	uNETix
nm	y	y	y	y	–	–
prof	y	y	y	y	–	–
(Pascal interp/ comp)	–	–	–	–	cp	–
(ranlib)	–	–	y	y	–	–
ratfor	–	–	y	–	–	–
regcmp	y	–	y	–	–	–
size	y	y	y	y	y	–
sno	y	–	–	–	–	–
spline	y	y	y	–	–	–
strings[1]	–	–	y	–	–	–
strip	y	y	y	y	–	–
time	y	y	y	y	–	–
tsort	y	y	y	y	–	–
xref	y	–	y	n	–	–
xstr[1]	–	–	y	–	–	–
yacc	y	y	y	–	–	–
SCCS commands	y	–	y	–	–	–

[1]Berkeley UNIX command
[2]Uses Lattice C compiler and associated Lantech Software Tools package

UNIX is known for its stellar program development commands, including compilers, interpreters, software engineering tools, and program verification and testing tools. A shortfall of uNETix is its scarcity of development tools.

A new version designed for the PC/AT is now available. PC/IX 1.1 runs on an AT in the real address mode, limiting memory addressing to 1MB. The C compiler still is limited to the small model. The upgrade fee is $40.

VENIX/86

UniSource is the exclusive licensed distributor of VentureCom's VENIX/86. In its current form, VENIX/86 is a port of AT&T's version 7 UNIX with many Berkeley extensions, including **vi**, the columnar version of the directory lister (**ls**), and the C shell (**csh**).

Because of its earlier vintage, VENIX/86 is a bit leaner in the UNIX commands it includes, compared to the two other licensed versions, PC/IX and XENIX. It occupies less disk space, leaving more room for user files or other operating systems. Several types of mass storage devices are supported. A second fixed disk installed on an XT must be the same type and size as the first for VENIX/86 to use it; DOS may reside on the disk with VENIX/86.

A full BASIC interpreter (which is a nonstandard UNIX program from the University of British Columbia) is available in addition to the C compiler and its support tools. No other UNIX language programs are included.

VENIX/86 compiles C programs in about the same time as a moderately loaded PDP-11/70 running BSD 4.2 UNIX. Because VENIX/86 is based on version 7, it does not have SCCS tools, commands for packing and unpacking files, etc. A set of DOS utilities are provided to permit exchanging files between DOS and VENIX/86.

The UniSource distribution includes a feature called Quad-Screen Picture Windows. Each window is a full screen and may be used to monitor a task or serve as a separate log-in port.

Someone with "super user" privileges can use the **nice** command to set very high priorities for tasks that require realtime attention. This is done at a serious performance cost to other running processes.

The documents for VENIX/86 are in five volumes, spiral-bound so that they lie flat. A few sections have acceptable indexes, but most have none. The dividers have no tabs and are fairly stiff, so it is a little difficult to flip through the pages to find subjects quickly.

UniSource provides VENIX/86 already installed on a fixed disk, ready for installation the easy way. Another company service allows potential customers to call a UniSource-supplied number and log in as a guest for a test drive on an IBM PC running VENIX/86.

AT&T is reportedly buying VENIX/86 for use on its PC 6300, and UniSource has announced that it will release System V VENIX, a version based on UNIX System V, in 1985. This version will provide binary compatibility across microcomputers so that the same software can be run on an XT, a DEC Rainbow, and the AT&T 6300. (At UniForum in Dallas last January, the Data General/One was running a floppy disk version of VENIX. It had the **vi** text editor, but no C compiler was available.)

XENIX

The Santa Cruz Operation is marketing XENIX for the PC/XT by way of Microsoft. (IBM is handling the marketing of the 80286 version of XENIX for the PC/AT. This will be reviewed in a future is-

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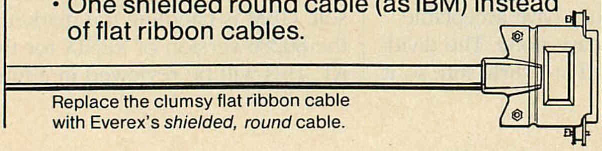

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sue of *PC Tech Journal.*) XENIX is a complete and competent system, blending a full and faithful UNIX System III with a set of useful Berkeley extensions and custom applications in a well-designed package. The system has been unbundled into three major packages that may be purchased separately. As the tables show, XENIX is a nearly complete UNIX implementation—only a few commands have been omitted.

XENIX has the most complete text processing package of any of the tested products. The memorandum macros (**mm**) package is supported by XENIX. Although loading all of the programs onto disk is not necessary, it would not hurt to do so if document preparation is to be a significant activity. If a suitable typesetter or printer is available, **troff** is a good choice. Otherwise, **troff** can be left out and **nroff** used instead.

Release 1.2 of the XENIX Development System was tested for this article. It is a complete UNIX software development package that also contains a set of useful Berkeley programs—**ctags**, **strings**, and **xstr**—that help bring order to the chaos of large-scale program development. In addition to this, the UNIX source code control system (SCCS) is provided. XENIX has neither **f77** nor **sno** in this release.

CMERGE is a recent addition to XENIX. It is a cross-development system that facilitates the creation of programs under XENIX for MS-DOS and PC-DOS machines. Appropriate libraries are provided to permit running and testing programs in both XENIX and DOS operating environments. Both the large and small models are supported for DOS programs, but only the small model may be used for XENIX programs in this release of the CMERGE compiler. A future release will add large-model support for 8086 XENIX.

In its current production version, XENIX can use one or two fixed disks with partitions of up to 16MB. SCO can describe methods of working with various brands of disks and controllers and XENIX can be configured for larger disks if necessary. I have loaded XENIX onto a 26MB disk in a modified PC/XT in a 16MB partition with PC-DOS in the remaining 10MB without any difficulty. Ideally, all XENIX system files should be on one fixed disk with all user file systems on a totally separate fixed disk. Since the IBM fixed-disk adapter can control two fixed disks, it's a relatively simple job to set up an XT this way to increase user file space.

XENIX uses color effectively, if it is available, and can run up to ten virtual terminals on the console. One virtual console (screen plus keyboard) may be active at any time. There is no provision for windows nor for simultaneous viewing of virtual consoles.

The Santa Cruz Operation provides five binders chock full of documentation. Two binders accompany the basic system, one comes with the text processing package, and two with the development system. The print quality of

XENIX is a complete and competent system, blending a full and faithful UNIX System III with a set of useful Berkeley extensions and custom applications.

the documentation is not as good as it could be, but the coverage is complete and the documents are well written. SCO adds some good starter tutorials that will help newcomers overcome the fear that is often associated with learning a system as complex as XENIX. Release notes now accompany each package, detailing which files are on each disk and providing special instructions that speed installation.

SCO has earned a reputation for excellent customer support of its XENIX products, offering reasonably priced service contracts at several levels of support and responding quickly to users' requests for assistance.

Microsoft and AT&T recently reached an agreement that will have Microsoft porting the latest official AT&T version of UNIX, so in the not-too-distant future, XENIX should be compatible with the standard version. SCO is planning to introduce its System V very soon.

COHERENT

Mark Williams Company's COHERENT system was introduced a few years ago to run on a standard PC equipped with a Corvus 5MB add-on hard disk. It was somewhat buggy and slowed down quickly under load, but was a remarkably complete version 7 UNIX look-alike. It has been improved and expanded in the intervening period and supports many of the major UNIX features. This is the most UNIX-like of the three look-alike systems tested.

The system is shipped on seven double-sided floppy disks (it used to be on 19 disks) and it can be installed in about 50 minutes using the installation procedure provided. The current installation procedure is less prone to fatal errors than were earlier versions.

COHERENT provides no **cu** or **uucp** functions. It includes a small model version of the Mark Williams C compiler. (Another compiler comparable to the Mark Williams MS-DOS C compiler, which can produce large model programs, is expected soon.) A reasonable set of program development support tools is included (see table 5).

The **nroff** text processor uses the manuscript macros (**ms**). The system has no **troff** or equivalent program for typesetters, but few users will notice until laser printers are much cheaper and in greater abundance.

Fixed-disk support is excellent. COHERENT will work with a partition of at least 5MB on an XT or on external disks by Corvus, Davong, Micronetics (SASI controller), and Tecmar. Any disk size (5-, 10-, 15-, and 26MB) may be used for either or both fixed disks.

The COHERENT documentation is the least well-packaged of the products reviewed here. The two bulky 8½-by-11-inch binders are filled with single-sided pages. However, the coverage and quality of the text is good, and excellent indexes accompany each of the major sections, a feature that is lacking in the documents provided with some of the other systems.

QNX

Quantum Software Systems has profited from being one of the first companies to supply a multitasking, multiuser operating system for the IBM PC. QNX is noted for its compactness and speed and the amount of usable business and networking software already available for it. It is suitable for realtime applications, too. Its scheduling algorithm allots shorter time slices and allows priorities to be assigned to processes to guarantee scheduled time.

Despite the similarity of its name (the original name, QUNIX, was shortened to QNX voluntarily by Quantam because it felt the name was too close to the real thing), QNX is not UNIX at all—although the two systems have several features in common, such as a hierarchical file system, C as a primary high-level language, and a few similar commands. In addition, some users will be disappointed in this system's lack of compatibility with UNIX syntax and overall capabilities in program develop-

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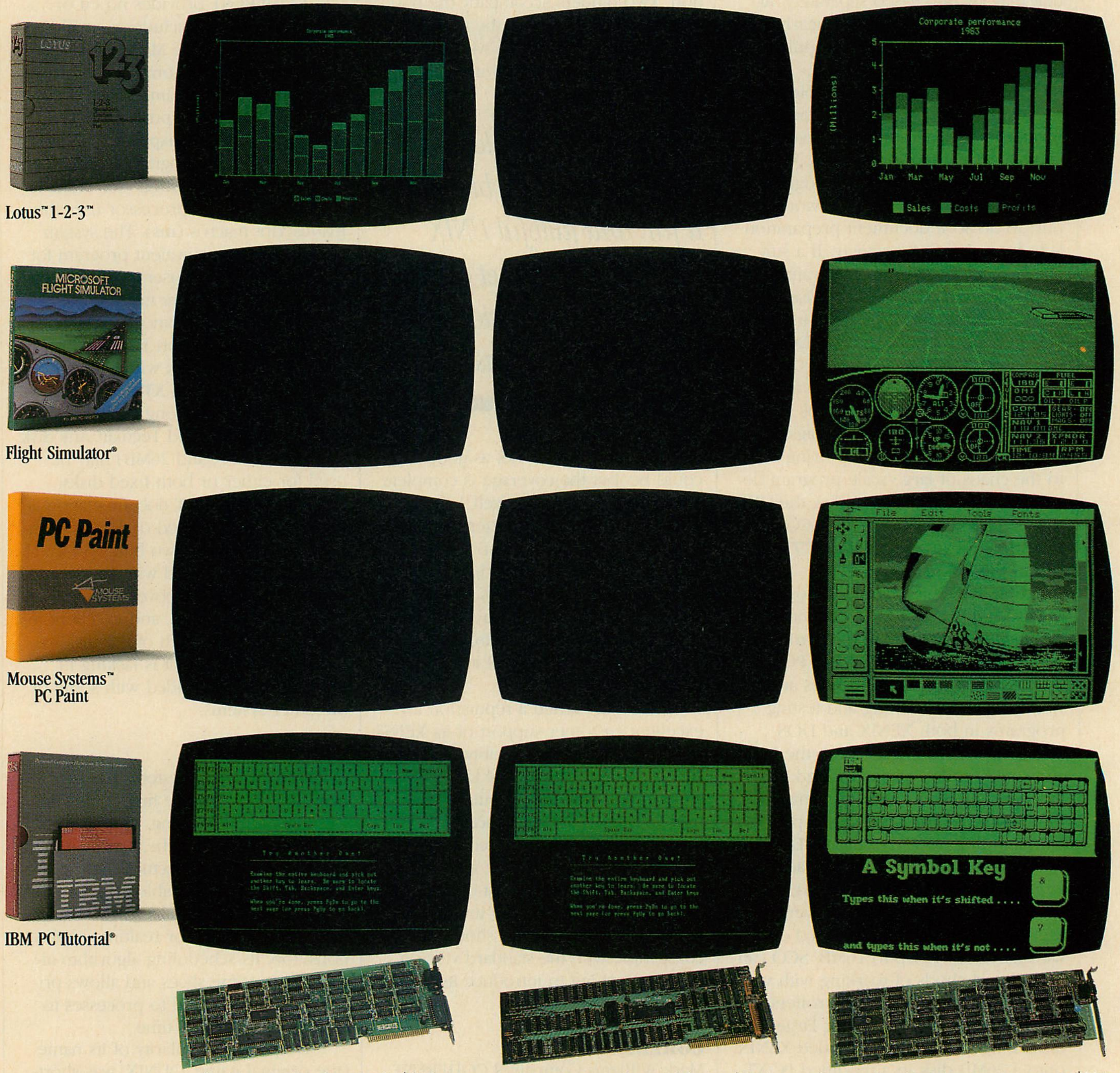

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ment and text processing. Recent versions of QNX have public domain versions of **make**, **lex**, and **yacc**.

The command names and options differ markedly from those of UNIX. For example, the UNIX **wall** (write all) command becomes **apb** under QNX, **pr** becomes **list**, **echo** becomes **type**, **ps** becomes **task**, **rm** becomes **frel**, and **rmdir** becomes **drel**. QNX has a word-processing style visual editor called **ed** and a line-by-line editor, **led**, which is similar to the UNIX **ed** program.

QNX has enough maturity to be relatively bug-free. Now Quantum is putting much of its energy into expanding the applications software base. New applications include a menu interface, an electronic mail system, a new BASIC compiler, and a raft of databases and spreadsheets to complete business management and accounting systems.

Earlier versions of QNX did not use floating-point software, so if a host machine did not have the needed hardware, programs were necessarily integer only. That has been changed in the latest version, which now has software floating-point routines that are used automatically when no 8087 math coprocessor is found to be present.

QNX uses shared runtime libraries and common modules for assembly, linking, and loading of programs. Only the compiler module differs for each supported language (C, BASIC, Pascal, Dibol). The size of executable programs is very small because of the runtime library approach, permitting a large number of files to be stored on each disk, but the full library must be memory-resident at all times. Yet even under those circumstances, QNX is able to run in as little as 128KB and can be placed in the computer's ROM.

The designers of QNX did a nice job of handling primary and secondary storage. QNX has drivers for a wide range of floppy and fixed disks and even for RAM disks of very large capacity. The latest release also runs on the AT in real address mode.

A local area networking version of QNX, 2.0, allows users on the network to share files and devices.

uNETix

This UNIX-from-scratch product by Lantech Systems provides an inexpensive way to make a gradual transition from PC-DOS to UNIX. The price is $49.95 for the UNIX-like kernel, a DOS emulator, and basic utilities. Each of the specialty modules, such as the Lattice C compiler, windows, the **vi** editor, and a VT100 terminal emulator cost extra.

The version of uNETix tested is single-user and can run on a floppy-disk-only system or on an XT in one or more partitions on the fixed disk. A multiuser version is also available. Either version must be booted from the master kernel floppy disk, but will run entirely from the fixed disk once the kernel is loaded into memory. File systems on floppy or fixed disks may be easily mounted and unmounted using

A massive effort is underway to enhance the acceptability of UNIX systems to nonprogramming professionals, especially to those who are business users.

standard UNIX commands. In fact, all optional features are delivered as mountable file systems with individual shell scripts that handle most of the messy work of installation.

The operating system is not fast, but it has adequate speed for most users, even when running several tasks simultaneously. uNETix implements only about one-third of the basic UNIX commands, and the shell lacks looping and flow control statements, so most existing shell scripts will be worthless under uNETix.

Some of the commands exhibit nonstandard behavior. The **pr** command, for example, recognizes several optional arguments that modify its operation, just as the UNIX **pr** command does, but under uNETix the options must be separated from each other and introduced by a dash; the UNIX **pr** command can take the options in groups with a single leading dash. Also, a simple shell script to print a columnar directory listing breaks because the **–t** option cancels printing of the header but not the footer, and the multicolumn feature does not work right. So, a UNIX shell script such as **ls | pr –t5** fails to produce the required output, even when it is typed with separate arguments (**ls | pr –t –5**) as required by the nonstandard syntax.

What makes uNETix especially attractive, besides the low price, are the DOS emulator, the windowing feature, and the integration facility. These permit multiple tasks to be run concurrently and data to be copied and spliced between tasks in a variety of ways. The integration facility even has a learn mode that memorizes sequences and relations and can apply them to other data sets, for example, to copy selected cells from a spreadsheet (running under DOS of course) into a database maintained by uNETix.

The windows can be treated as up to ten separate consoles, or they may be overlaid on a single screen. The DOS emulator executes as a task under uNETix from any window and can run many of the best-selling programs designed for PC-DOS—although this operation requires a lot of memory. To run DOS built-in commands, 320KB is needed; and 448KB is needed to run a typical application that would require 128KB under DOS.

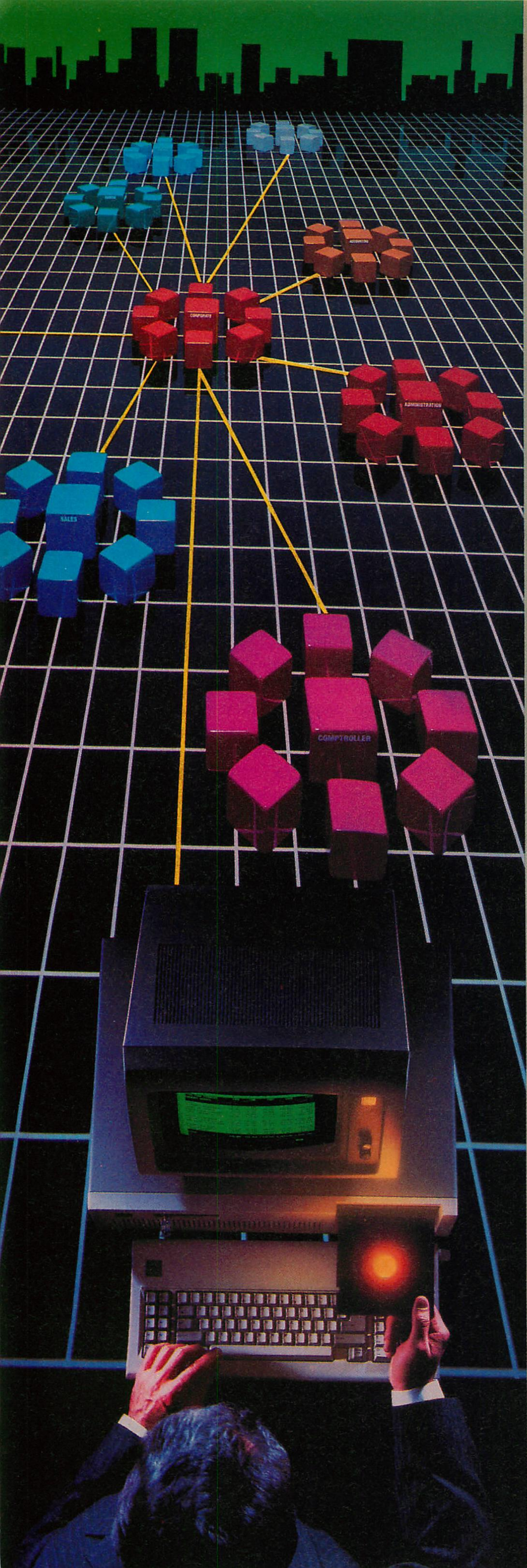
Lantech used the Lattice C compiler for uNETix. A few revisions were made to the compiler package to emulate the UNIX command syntax and operation of the various steps in the compile, assemble, and link sequence. The compiler produces reasonably sized program files that load and run quickly. A Lantech assembler and support tools are provided with the compiler.

The shortfall of uNETix, when compared to UNIX, is most clearly seen in tables 4 and 5. It has virtually no text processing capabilities and only a few program development tools. As an introduction to UNIX and networking, it is a dandy package. As an environment for serious design and development work, it leaves far too much out to be of value to many users.

SPECIAL FEATURES

A massive effort is underway to enhance the acceptability of UNIX systems to nonprogramming professionals, especially users who are in a business environment. For that reason, UNIX providers are promoting visual and menu shells, DOS emulation facilities, multiple virtual consoles, and various forms of windowing for UNIX.

A DOS emulation facility permits DOS to run as a task under UNIX, making nearly all existing DOS programs available to UNIX users immediately. This requires a great deal of memory, especially for programs such as Lotus 1-2-3 and other integrated business packages. The DOS Connector, which is available from Uniform Software Systems for the XT, works with PC/IX and XENIX. A version of the DOS Connector that works with VENIX/86 is available from UniSource. The latest DOS Connector release can operate with IBM's


COMPTROLLER
ADMINISTRATION

TopView and runs on the AT. Lantech's uNETix, as noted earlier, includes a DOS emulator with similar capabilities as part of its basic package.

An alternative approach is to port the most popular DOS applications to UNIX. That is not a trivial task. Multiuser capabilities imply that only one user will have direct access to the PC's console. All other users will likely have remote terminals. Most of the programs of interest use some tricks under DOS to obtain instant screen updates that are not easily achieved under UNIX on a dial-up port running at 1200 baud, or even at much faster speeds. Also, many of the programs depend on the extra keys available on a PC keyboard that are not available on most video terminals. The result is some very awkward combinations of key sequences in order to simulate a simple function key press on the PC keyboard.

Another reason that DOS applications are not easily ported to UNIX has both technical and legal ramifications. Copy protection schemes employed in some top-selling programs are difficult to implement in a UNIX environment, and the concept of one user per copy of the program is impossible to enforce when programs are meant to be shared among many users. The usual response by the manufacturer is a contract or licensing agreement that pegs the price of the product to a maximum expected number of users or to a machine type.

Thus far, most suppliers of DOS applications have avoided the UNIX market, probably because it is currently perceived as too small to warrant a potentially difficult development effort. Microsoft is taking action that will positively affect the perception and growth of the UNIX market. Multiplan is available from SCO (see table 1) for XENIX on the XT and is available from other sources for many other UNIX systems. Other Microsoft products that have been known to DOS users for some time are beginning to show up in UNIX garb. This will help to ease the transition from DOS to UNIX for many users by providing some familiar software in the new environment.

Of course, DOS applications are not the only programs worth using. Several successful business applications for minicomputer and mainframe UNIX systems have been tailored to the PC UNIX market. SCO sells INFORMIX by Relational Database Systems for the PC, XT, AT, and most compatibles that can run XENIX (see table 1). INFORMIX is an excellent relational database management system that features forms-oriented query and data entry, a general-purpose report writer, full audit trail capabilities, and interfaces to COBOL ISAM files and to C programs.

Another relational database management system for UNIX, Unify, is available from Unify Corporation. It is a full-featured DBMS that runs on the AT under XENIX, on the XT with the Sritek 68000 board and XENIX, and on XT and AT models running VENIX/86. The Unify Corporation uses overlays of relatively small modules for each major task to run on systems with limited memory and to gain a claimed 40-percent speed improvement over most other UNIX-based DBMS products.

If a UNIX system is not brought down correctly, the file system may be damaged and files could be corrupted or lost altogether. This is due to the way in which UNIX buffers disk activity.

Another prime area of interest to business computer users is word processing. Integrated word processors, typified by WordStar and Microsoft's Word, have only recently started to show up on UNIX systems. The traditional UNIX approach has been to segregate the editing from the processing steps. Both types of systems are available to PC UNIX users.

In the integrated category, SCO sells Lyrix as an option for XENIX (see table 1). Lyrix has all of the expected features, such as full-screen editing, on-screen formatting, cut-and-paste operations, a mail merge facility, printer control and queuing, and interactions with the file system. It also has search (and replace), spelling checking, and a virtual terminal interface.

The Professional Writers' Package from Emerging Technology Consultants is an example of the divide-and-conquer approach. The package consists of EDIX, WORDIX, SPELLIX, and INDIX grouped together to operate from a main menu. AT&T announced at the Office Automation show in Atlanta this past winter that the Professional Writers' Package is available for its line of UNIX systems. Emerging Technology also makes the product available on an OEM basis for use with other UNIX systems.

The point is that an important factor to consider when choosing systems and software is portability. Users want to be able to use the same editor, the same database manager, the same basic command set, the same everything on any computer they use in the course of their business. That is a goal that will never be achieved completely perhaps, but UNIX comes closer to it than any other computing environment.

UNIX systems generally tend to be large and complicated. A prime example of trouble caused by operator error can occur when the system is going to be turned off. If a UNIX system is not brought down correctly, the file system may be damaged and files could be lost or corrupted. This is due to the way UNIX buffers disk activity. With most UNIX systems, it is necessary to run a special shutdown program that flushes the buffers to disk and otherwise does an orderly exit.

Because of the complexity of UNIX, the importance of good vendor support cannot be overstated. The system supplier should be selected with the same care as for any other big ticket item. A lot of time and energy will be devoted to using UNIX, so the user should have a partner to help make it work right.

The most likely PC UNIX users are program development organizations in which cooperation among developers is essential. They will appreciate the ability to share and protect data simultaneously. Word-processing operations can benefit from the many useful tools that are provided with UNIX. Writers can put their prose to the test with Writer's Workbench or programs of a similar ilk that are found on most UNIX systems. Small businesses will find UNIX to be suitable for a wide range of tasks, from office helper to graphics preparer. It can even help with taxes.

Before anyone commits to a UNIX or UNIX-like system, a complete assessment of perceived needs and real requirements should be made. It should be obvious that if a user's sole purpose is to play with the flight simulator, he does not need UNIX. On the other hand, someone who is doing program development or documentation on almost any scale will be hard pressed to find a better operating environment.

Augie Hansen spent seven years with Bell Laboratories and AT&T before starting Omniware, a software development and training firm specializing in UNIX and MS-DOS systems and applications.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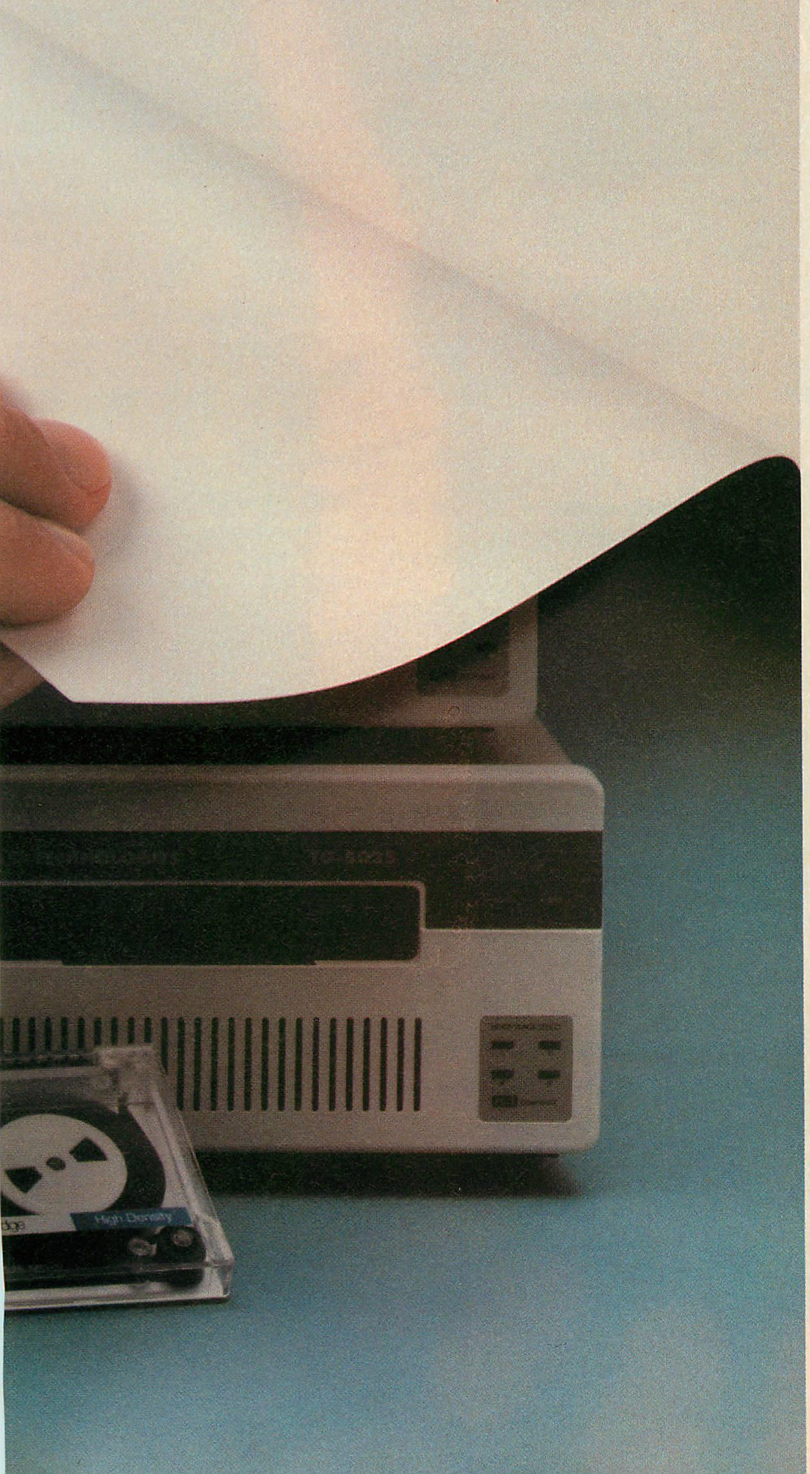

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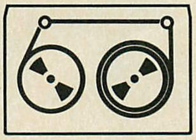

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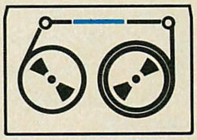

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Building Device Drivers

Routines and modules to help write customized character device drivers

STAN MITCHELL

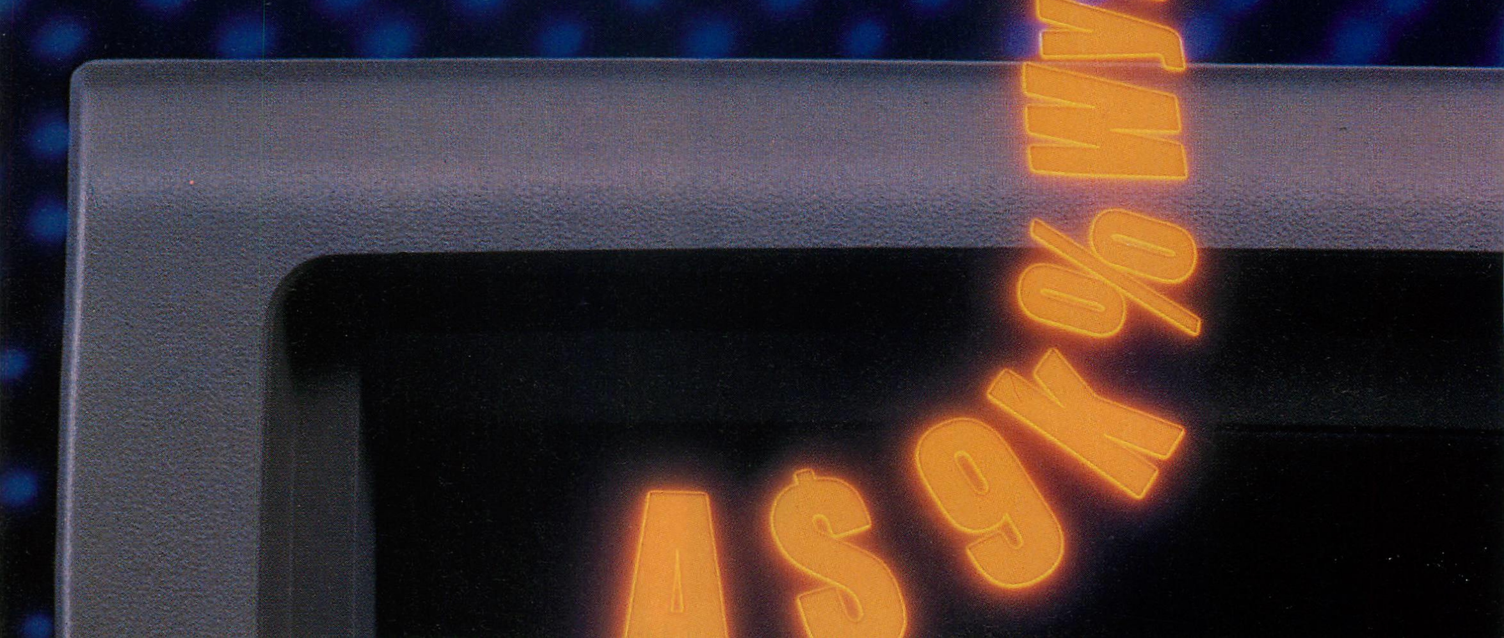
Many system users, casual programmers, and hardware designers look upon the task of writing a device driver with something approaching dread, at least partially because the IBM documentation of device drivers and how they are written is minimal and includes few examples.

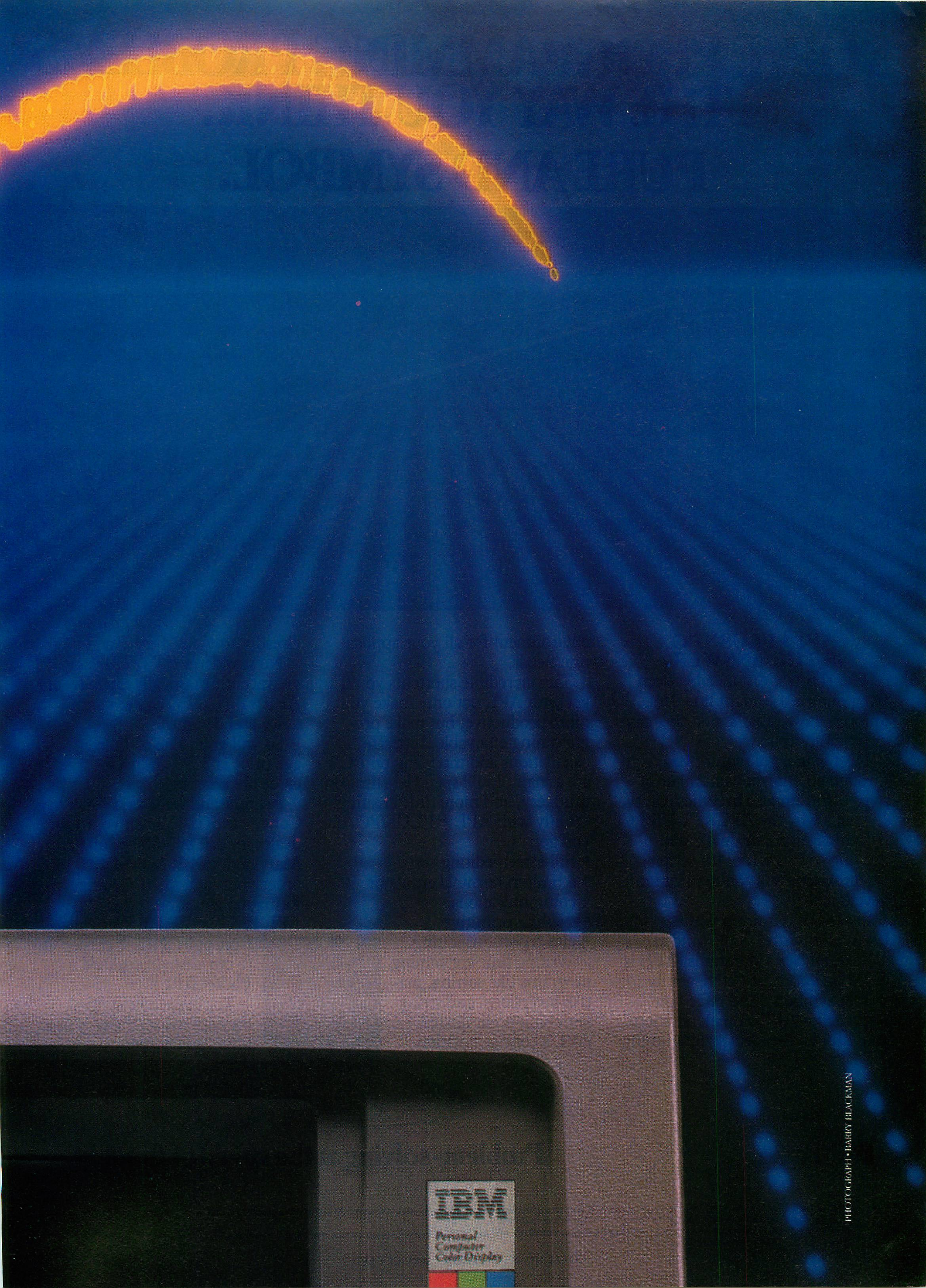
The most difficult part of writing a device driver is getting the framework right—knowing how to set it up so that DOS can install the driver and applications can use it. What this article offers is a generalized device driver "front end;" the more arcane tasks of creating the driver are given to a group of macros. This structure allows attention to be focused on the job at hand—how to control a device and tap its capabilities.

Before the details of device-driver construction can be discussed fully, the characteristics of devices, as the system views them, must be examined.

Exactly what is a DOS device, anyway? A device is simply a place to and from which bytes travel. Usually this place has a physical counterpart—a hardware peripheral of some kind—that is actually generating or using the bytes that are coming from or going to the device. A CRT is a device that receives bytes, as is a printer. A keyboard is a device that emits bytes, and so on.

Two types of devices exist: character and block. Character devices send or receive bytes one at a time. Block devices (which will not be discussed here) are generally disk drives or disk-





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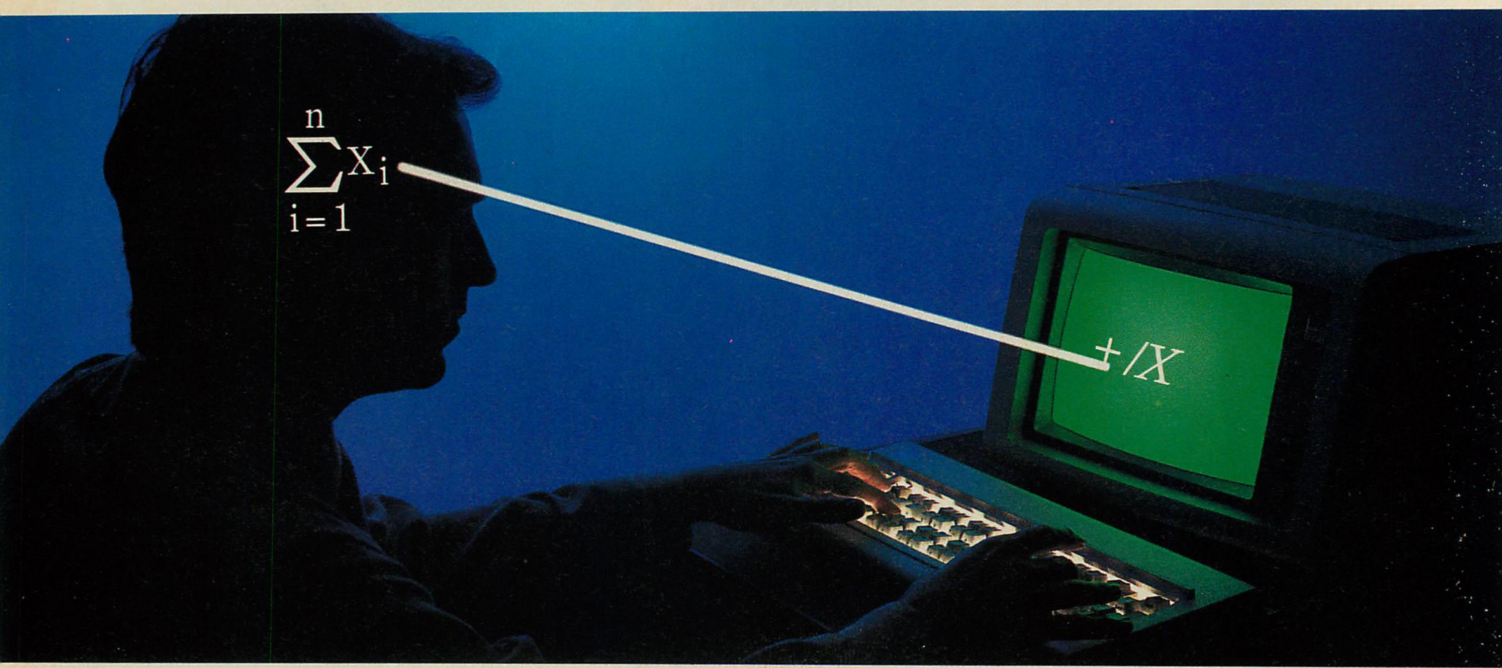

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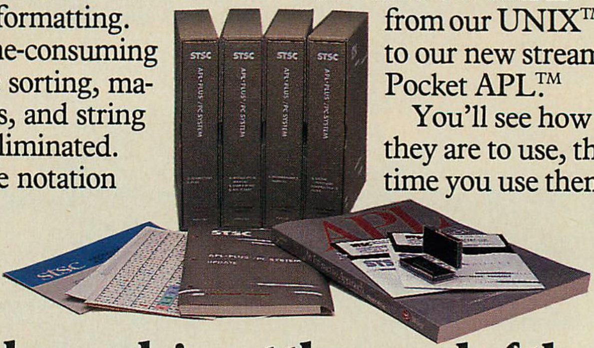

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drive emulators, and they send or receive a block of bytes at a time; a block typically consists of a physical sector of the disk drive. For more details about block devices, see the PC DOS *Technical Reference* manual, which contains a sample block device driver in source form for a "ramdisk" program.

THE DEVICE CHAIN

Device drivers are programs created to control particular devices; DOS loads them at boot time. DOS creates a one-way linked list of system device drivers during the boot process. Each node in the list is an 18-byte data structure called a device header. The first four bytes of each device header comprise a 32-bit pointer in segment:offset form that points to the next node in the list.

The first node is embedded in IBMDOS.COM and corresponds to the NUL device, a "bit-bucket" device that absorbs everything sent to it and emits nothing. The last node is identified by a value of FFFFH in the offset portion of the 32-bit pointer to the next node.

The address of the first device header is found by opening the NUL device with DOS function 0FH using an FCB. DOS returns a pointer to the NUL device header in one of the reserved fields of the FCB. Links to succeeding headers are provided by the next device header pointer field.

Table 1 shows a sample device header chain. The contents of each device header have been presented in a more readable format than that provided by a raw dump in hexadecimal notation. Note that the Next Header field for each device becomes the starting address for the following device in the chain. Also note the FFFFH value in the offset part of the last Next Header field, indicating the end of the chain.

The format of a device header memory image is given in figure 1. The name and attribute words are user-selectable and reflect the function of the device. The attribute word is a bit map that indicates to DOS whether or not the driver has certain special properties, as explained below. Other entries are determined by driver placement in memory and by the system configuration. The strategy and interrupt fields are offsets into the segment begun by the first byte of the header.

The interface between DOS and devices was designed with multitasking in mind. The intent was to allow each device in a multitasking environment to maintain its own queue of requests for its services. The DOS executive would periodically scan its queue of pending requests for completions and wake up waiting processes. A device request would call the strategy entry point, which would simply queue up the request in the form of a request header and return. Upon completion, a device would receive an interrupt and its service routine would post results in the corresponding request header. Before returning, the device would check again for waiting requests.

This capability has not been used in DOS versions 2.0, 2.1, or 3.0, none of which handles multitasking. Once a multitasking version of DOS is released, requests for device services almost certainly will be handled this way. In current DOS releases, the strategy entry point is used to pass a 32-bit pointer to a request block that is not queued. Next, an immediate call is made to the interrupt entry point. Here the request is serviced, and results are passed back in the request block.

The strategy and interrupt entry points do not have an explicit segment in the device header. The segment address is given by the link pointer of the preceding device header. The segment portion of the address for the strategy and interrupt entry points is the same as the segment address of the header.

As mentioned earlier, devices are either character type or block type, depending on the way the driver deals with data. Figure 2 shows definitions of bit fields in the attribute word of a device header. If bit 15 = 1, the device is a character device; otherwise it is a block device. For character devices, the following bits are significant: IOCTL (bit 14), OCREM (bit 11), SPECIAL (bit 4),

TABLE 1: *Device Header Chain with Resident Devices*

STARTING ADDRESS	NEXT HEADER	ATTRIBUTE	STRATEGY ENTRY PT.	INTERRUPT ENTRY PT.	DEVICE NAME
0128:0154	0070:015D	8004	0128:15A2	0128:15A8	NUL
0070:015D	0070:01EE	8013	0070:00AE	0070:00B9	CON
0070:01EE	0070:029D	8000	0070:00AE	0070:00BF	AUX
0070:029D	0070:0317	8800	0070:00AE	0070:00CE	PRN
0070:0317	0070:03E3	8008	0070:00AE	0070:00E3	CLOCK$
0070:03E3	0070:0200	0800	0070:00AE	0070:00E9	04
0070:0200	0070:02AF	8000	0070:00AE	0070:00BF	COM1
0070:02AF	0070:0AAB	8800	0070:00AE	0070:00CE	LPT1
0070:0AAB	0070:0ABD	8800	0070:00AE	0070:00D4	LPT2
0070:0ABD	0070:0ACF	8800	0070:00AE	0070:00DA	LPT3
0070:0ACF	0070:FFFF	8000	0070:00AE	0070:00C5	COM2

Note that the address in the Next Header field for each device becomes the starting address for the device that follows it in the Device Header chain.

TABLE 2: *Device Header Chain with Two Installed Devices*

STARTING ADDRESS	NEXT HEADER	ATTRIBUTE	STRATEGY ENTRY PT.	INTERRUPT ENTRY PT.	DEVICE NAME
0128:0154	085F:0000	8004	0128:15A2	0128:15A8	NUL
085F:0000	*07EC:0000	C000	085F:0036	085F:0041	PRN
07EC:0000	*0070:015D	8013	07EC:0037	07EC:0042	CON
0070:015D	0070:01EE	8013	0070:00AE	0070:00B9	CON
0070:01EE	0070:029D	8000	0070:00AE	0070:00BF	AUX
0070:029D	0070:0317	8800	0070:00AE	0070:00CE	PRN
0070:0317	0070:03E3	8008	0070:00AE	0070:00E3	CLOCK$
0070:03E3	0070:0200	0800	0070:00AE	0070:00E9	04
0070:0200	0070:02AF	8000	0070:00AE	0070:00BF	COM1
0070:02AF	0070:0AAB	8800	0070:00AE	0070:00CE	LPT1
0070:0AAB	0070:0ABD	8800	0070:00AE	0070:00D4	LPT2
0070:0ABD	0070:0ACF	8800	0070:00AE	0070:00DA	LPT3
0070:0ACF	0070:FFFF	8000	0070:00AE	0070:00C5	COM2

**Installed Devices*

The NUL device's position at the root of the Device Header Chain prevents another NUL being loaded before it: NUL is the only device that cannot be preempted.

CLOCK (bit 3), NUL (bit 2), STDOUT (bit 1), and STDIN (bit 0).

Bits 0-3 of the device's attribute word are flags that indicate to DOS whether the device is one of three devices treated specially by DOS. The NUL device has a unique device driver embedded in IBMDOS.COM and cannot be altered. The NUL bit is a flag that tells DOS that this driver is to be used for the NUL device. For a device that is to be used as the standard I/O device, the pair of bits STDOUT and STDIN are set. Similarly, the CLOCK bit is set on any device used as the clock device.

The other three bits of the attribute word are concerned with capabilities of the device driver. The SPECIAL bit (which is described in the MS-DOS *Programmer's Reference*) indicates that a standard I/O device driver has installed an INT 29H handler for output. This special handler is meant to provide fast output to the console. For the IBM PC, the IBMBIO CON device uses the write TTY function of INT 10H for fast console I/O and calls it through a short INT 29 service routine. The IOCTL bit indicates that the device driver supports input and/or output of control strings via DOS function 44H. The OCREM (Open/Close/REMovable) bit became available with DOS version 3.0. This bit is described in DOS 3.0 documentation, however, a name has not been assigned to it. For a character device, it indicates that the device driver supports open and close functions. For a block device, it indicates that the driver supports removable media.

In the case of character devices, the name field of the device header is an array of eight ASCII characters, making up a legal file name. Instead of names, block devices are given unit numbers. For block devices, the first byte of the name field contains a count of the units supported by the driver, expressed in binary form. The rest of the name field is not used.

The default configuration of DOS does not allow a device and a file to share the same name. An undocumented CONFIG.SYS command removes this restriction but makes device references more verbose. To use this undocumented command (which is *not* available under DOS 3.0), add the line AVAILDEV=FALSE to the CONFIG.SYS file. Setting AVAILDEV to FALSE requires that all device references have the form \DEV\<devname>. For example, the standard I/O device is named CON. If AVAILDEV is FALSE, CON, without \DEV, could refer only to a file. The default set-up, AVAILDEV=TRUE, would

FIGURE 1: *Memory Image of Device Header*

	NEXT HEADER		ATTR	STRAT	INTRPT	DEVICE NAME
OFFSET	0 1	2 3	4 5	6 7	8 9	10 11 12 13 14 15 16 17 18
BYTE	L H off	L H seg	L H	L H	L H	

The device name and attribute word fields used in the device header may be selected by the user; they reflect the function to be performed by the device.

FIGURE 2: *Bit Map of Attribute Word*

	MOST SIGNIFICANT BYTE								LEAST SIGNIFICANT BYTE							
BLOCK DEVICES	0	0	1	X	1	X	X	X	X	X	X	0	0	0	0	0
BIT	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
CHAR DEVICES	1	1	0	X	1	X	X	X	X	X	X	1	1	1	1	1
BIT NAME	CHR	IOCTL	IBM		OCREM							SPECIAL	CLOCK	NUL	STDOUT	STDIN

A bit given as 0 is not used for a device type while a bit given as 1 has meaning for a device type. If bit = x, it is not defined; always force such bits to 0.

allow the standard I/O device to be specified as either CON or \DEV\CON, but which would then forbid another file to have the name CON. Remember that when commands are undocumented, it is usually for a reason.

One of the advantages of MS-DOS over the earlier CP/M operating system is the relative ease with which the Basic I/O System (BIOS) can be extended, allowing users to install devices without rewriting the BIOS.

For the IBM PC family, the BIOS resides in IBMBIO.COM. The device header chain in table 1 is based on the resident BIOS provided by DOS 3.0. The devices provided for are the same as in versions 2.0 and 2.1. Besides NUL, which is always present, MS-DOS requires a minimum of four devices in the system-initialization code. These devices are those that follow NUL in table 1: CON, AUX, PRN, and CLOCK$. The device names are unimportant, but the function each performs must correspond to the following sequence: standard I/O device, auxiliary I/O device, listing device, and the realtime clock.

After these four devices have been installed, additional resident devices are installed. These resident devices are used to initialize DOS. When installation is complete, an attempt is made to open CONFIG.SYS on the boot drive. If CONFIG.SYS exists, it is read into a buffer and the contents are parsed into commands.

The command line for adding a device is as follows:

```
DEVICE=[d:][path]filename[.ext]
   [parameters]
```

For example, the command

```
DEVICE=c:\util\logcon.sys /L
```

could be used.

The items in square brackets are optional and include drive and path specifiers as well as a parameter field following the file name. A pointer to the command line following the equal sign is passed to the device driver when initialization code is first called as the devices are installed. The driver can parse and make use of any parameters. Device files are binary memory images

that do not use the Program Segment Prefix; thus, they are ORGed at 0000H.

When a new device is installed, it is added to the linked list at the link immediately following the NUL device. This addition is done in two operations: first, the Next Header pointer in the NUL device header is moved into the Next Header field of the device header to be installed; second, the Next Header field in the NUL device is replaced with the segment:offset address of the newly installed device header and driver. New drivers are thus added to the linked list at the root (NUL), pushing previously-installed drivers farther down the list.

Installed device drivers get the lowest DOS memory allocation. COMMAND.COM loads in above them, as do any "terminate and stay resident" programs. Consequently, if an application requires memory in the first 64KB (DMA channel 1, for instance), a device driver could be used to reserve a buffer in the lowest available RAM.

Before DOS can access a device, that device must be opened using function call 0FH or 3DH. If a device is opened with function 0FH, it can be read from and written to with DOS functions 14H and 15H. If function 3DH is used, a 16-bit file handle that is associated with the device is returned. Input, output, and I/O control functions that work with a file handle require that the device be opened with DOS function 3DH rather than function 0FH.

Before the CONFIG.SYS file is parsed, the standard I/O devices are opened on return from the initialization call to DOS. DOS function calls 01H through 0CH are therefore available at this time, using the default resident drivers. File operations are not recommended at this time, however, because DOS is in the process of setting up its buffers. Memory allocation calls are also off limits, because the current allocation is still growing to incorporate the configuration parameters specified in CONFIG.SYS. One DOS function that *is* safe to use (and that may be useful when a device driver is initialized) is 30H, which returns the DOS version number.

Remembering which DOS calls are valid during this phase of the boot process is important, because as each device driver is installed, a portion of it is executed. The device initialization code primes the device so that it will be in a predictable state on the first input, output, or other DOS request. The initialization code also tells the device-installation routine which portions of the device-driver file should be kept after the initialization is complete and which should be thrown away. Throwing away part of this file saves space and can be done because initialization code usually needs to be executed only once.

Once the CONFIG.SYS file has been completely parsed, all of the initial standard device handles are closed and then reopened so that user-installed device drivers can preempt the default drivers for CON, AUX, and PRN. When a device handle is opened, the first device in the linked list that matches its name is used to satisfy the request. This allows duplicate device names to be included in the CONFIG.SYS file for CON, AUX, and PRN.

Because installed devices are inserted immediately after the head of the chain, a user-installed CON, AUX, or PRN device driver will be found before the DOS-supplied default drivers for these devices. Note that the position of the NUL device prevents another NUL being loaded before it. NUL is thus the only device that cannot be preempted. Table 2 shows a device header chain containing two user-installed devices.

FIGURE 3: *Memory Image of Request Header*

STATIC REQUEST HEADER

	LNG	UNIT	CMD	STATUS		DOS QUEUE				DEVICE QUEUE			
OFFSET	0	1	2	3	4	5	6	7	8	9	10	11	12
BYTE				L	H	L	H	L	H	L	H	L	H
						off		seg		off		seg	

ADDITION FOR .INIT

	# UNITS	BREAK ADDRESS				BPB PTR/PARM FIELD PTR			
OFFSET	13	14	15	16	17	18	19	20	21
BYTE		L	H	L	H	L	H	L	H
		off		seg		off		seg	

ADDITION FOR .ND_INPUT

	LOOK AHEAD CHAR
OFFSET	13
BYTE	

ADDITION FOR .OUTPUT, .VOUTPUT, .INPUT, .IOCTL_IN, .IOCTL_OUT

	MEDIA	XFER BUF ADDR				BYTE CNT		START SEC	
OFFSET	13	14	15	16	17	18	19	20	21
BYTE		L	H	L	H	L	H	L	H
		off		seg					

The first 13 bytes of a request header use the standard format. Additional bytes must be appended for certain function calls to handle device-specific needs.

FIGURE 4: *Bit Map of Request Header Status Word*

	MOST SIGNIFICANT BYTE								LEAST SIGNIFICANT BYTE							
BIT	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
BIT NAME	ERR	. . . reserved . . .					BUSY	DONE	. . . . error code							

If an error return is made, an error code must also be included in the request header status word before control can be returned safely to DOS.

INSIDE A DEVICE DRIVER

Device Header. A look at a sample printer driver will help illustrate how this theory is put into practice. In listing 1, DD_MAC.MAC, the macro DEVHDR is used to build a device header. The attribute word ATTRIB is defined by an equate in listing 2, DD_DEF.MAC. It

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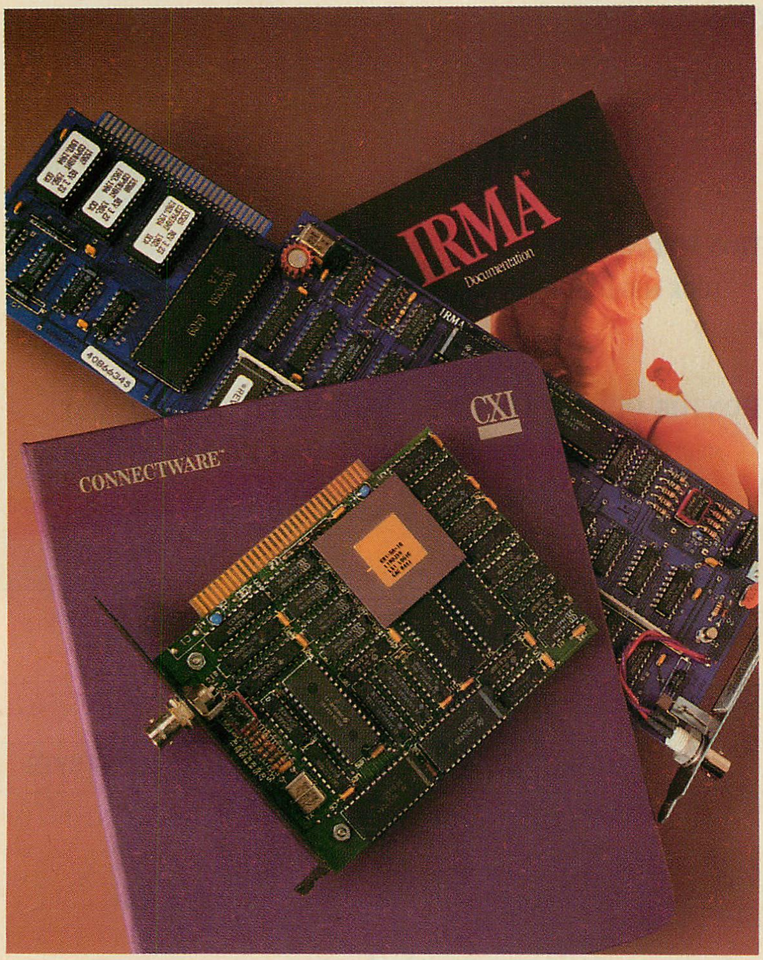

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FIGURE 5: *Location of Empty Driver*

```
-f300,340,00                        zero fill FCB
-a301
0D51:0301  db 'prn     '            add device name
0D51:0309  db '   '
0D51:030C
-a100
0D51:0100  mov dx,300               pointer to FCB
0D51:0103  mov ah,0f                open function
0D51:0105  int 21
0D51:0107  nop 0D51:0108
-g107                              now execute

AX=0F00  BX=0000  CX=0000  DX=0300  SP=FFEE  BP=0000  SI=0000  DI=0000
DS=0D51  ES=0D51  SS=0D51  CS=0D51  IP=0107   NV UP EI PL NZ NA PO NC
```

```
0D51:0107 90            NOP

-d300,32f                           AL=0 so open succeeded

                                                   dump out FCB...
0D51:0300  00 70 72 6E 20 20 20 20-20 20 20 20 00 00 80 00   .prn        ....
0D51:0310  00 00 00 00 45 0A 1A 50-01 40 00 00 5F 08 00 00   ....E..P.@.._...
0D51:0320  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
-d31a,31d   this reserved field (for DOS 3.00) points to device header
0D51:0310                                00 00 5F 08                ..._.

-d085f:0000L12   now dump the 18 bytes of the header
085F:0000  00 00 EC 07 00 C0 36 00-41 00 50 52 4E 20 20 20   ..l..@6.A.PRN
085F:0010  20 20
```

The driver is loaded at boot time; here its location is determined. Note that the offset to the device header pointer depends on the DOS version; the offset for DOS 3.0 is shown. For DOS 2.x, it is 19H from the beginning of the FCB buffer.

FIGURE 6: *Testing .IOCTL_IN Function in PRNMOD.ASM*

```
-f350,38f,0                    Make a request header
-a350
0D58:0350  db 1a,0,3           set length=26 function=3
0D58:0353

-a35e
0D58:035E  dw 0370             transfer buffer at 0d58:0379
0D58:0360  dw 0d58
0D58:0362  db 3                3 bytes transferred
0D58:0363

-a108                          Now set up calls to strategy/
                               interrupt entry points
0D58:0108  push ds
0D58:0109  pop es
0D58:010A  mov bx,350          ES:BX points to our request header
0D58:010D  call 085f:0036      this is the strategy call
0D58:0112  nop
0D58:0113  call 085f:0041      this is the interrupt call
0D58:0118  nop
0D58:0119

-g113                   Start execution ....

AX=0F00  BX=0350  CX=0000  DX=0300  SP=FFEE  BP=0000  SI=0000  DI=0000
DS=0D58  ES=0D58  SS=0D58  CS=0D58  IP=0113   NV UP EI PL NZ NA PO NC
```

```
0D58:0113 9A41005F08    CALL    085F:0041

-t                      Break. Now entering interrupt routine.

AX=0F00  BX=0350  CX=0000  DX=0300  SP=FFEA  BP=0000  SI=0000  DI=0000
DS=0D58  ES=0D58  SS=0D58  CS=085F  IP=0041   NV UP EI PL NZ NA PO NC
085F:0041 9C            PUSHF


                        Now in interrupt entry routine
-g085f:00c8             Go full speed until .IOCTL_IN entered...
AX=0006  BX=0350  CX=0003  DX=0300  SP=FFD6  BP=0000  SI=0018  DI=0370
DS=085F  ES=0D58  SS=0D58  CS=085F  IP=00C8   NV UP EI PL NZ NA PE NC
085F:00C8 E3FA          JCXZ    00C4

-t2                     Break. Registers are as expected on entry.
                         Continue in single step mode...

AX=0006  BX=0350  CX=0003  DX=0300  SP=FFD6  BP=0000  SI=0018  DI=0370
DS=085F  ES=0D58  SS=0D58  CS=085F  IP=00CA   NV UP EI PL NZ NA PE NC
085F:00CA BE4001        MOV     SI,0140

AX=0006  BX=0350  CX=0003  DX=0300  SP=FFD6  BP=0000  SI=0140  DI=0370
DS=085F  ES=0D58  SS=0D58  CS=085F  IP=00CD   NV UP EI PL NZ NA PE NC
085F:00CD 8A04          MOV     AL,[SI]
DS:0140=46
```

This session shows the conservative method of testing device driver functions: add the function modules, reload the device driver, and test each individual function by direct calls. Here the .IOCTL_IN function is tested in PRNMOD.ASM.

consists of a selection of attribute bit fields that are ORed together to form a single word.

The printer driver is a character device (bit 15 = 1) that supports I/O control strings (bit 14 = 1); when these two bits are ORed together, they produce the attribute word C000H. The device name (here, a replacement for default driver PRN) is the ASCII string PRN plus blanks to bring it up to eight bytes. The macro MKNAME takes the label entered in DD_DEF.MAC and converts it to a series of eight constants, N1 through N8. This was done to localize editing to a single file.

The other three entries in the device header are labels of data structures or executable code. NEXTo is the offset to the next device header in this file. Because only one device is defined in this device file, the value −1 is used to indicate that it is the last device header in this device file. STRAT_ENT and INT_ENT are labels for the strategy and interrupt entry points in the module ENTRY.ASM (listing 3).

The Entry Points. The strategy entry point in ENTRY.ASM, STRAT_ENT, takes a 32-bit pointer passed to it by DOS in ES:BX and stores it. This is a pointer to a request header. The first 13 bytes of a request header use the standard format shown in figure 3. Additional bytes may be appended to the structure for certain types of function calls.

The interrupt entry point in ENTRY.ASM, INT_ENT, is called immediately after DOS has returned from the strategy entry. The interrupt routine preserves the state of the caller by means of the series of PUSH and POP instructions at the entrance and exit of the routine. Three pieces of information are extracted from the request header: the function code, the byte count, and the transfer-buffer address.

If the function code exceeds the highest valid function code for the selected DOS version, an error return is made. If the selected function code is valid, it is doubled and added to the base of the function entry point table in order to get the address at which execution will continue. The byte count and transfer buffer address are used to pass data back and forth between the driver and the calling logic.

Before control is returned to DOS, all calls to the interrupt code must set appropriate bits in the status word of the request header. If an error return is made, an error code must also be included in the returned status. The format of the status word is shown in figure 4. Many of the defined error codes

FIGURE 7: *The CTTY Function of COMMAND.COM*

```
        .
        .
        .
NAME:   DB      'NEWDEV',0  ;name of new console device

CTTY:   PUSH    CS
        POP     DS
        ; first open new console device to get a temp handle
        MOV     DX,OFFSET NAME
        MOV     AX,3D02H        ;open new console device
        INT     21H             ;for reading/writing
        JC      NO_DEV          ;  exit if open fails
        ; now check that it is a device and not a file
        MOV     BX,AX           ;device handle to BX
        MOV     AX,4400H        ;get device info in DX
        INT     21H             ;
        TEST    DL,80H          ;is it a device?
        JZ      NOT_DEV         ;  exit if not
        XOR     DH,DH           ;clear high byte
        ; set the attribute bits for STDIN and STDOUT
        OR      DL,03H          ;
        MOV     AX,4401H        ;set device info using DX
        INT     21H             ;
        PUSH    BX              ;save handle of new device
        ;now shut down the current standard console device
        MOV     CX,3
        XOR     BX,BX           ;BX =STDIN handle (0000)
STD:    MOV     AH,3EH          ;close STDIN,STDOUT,STDERR
        INT     21H             ;
        INC     BX              ;BX = STDOUT(0001) / STDERR(0002)
        LOOP    STD             ;  handles, close them all
        ;now    copy the new device handle to handles 0,1,2
        POP     BX              ;restore handle of std device
        MOV     AH,45H          ;duplicate new std device handle
        INT     21H             ;  in handle 0000
        MOV     AH,45H          ;
        INT     21H             ;  in handle 0001
        MOV     AH,45H          ;
        INT     21H             ;  in handle 0002
        ;now get rid of temp handle
        MOV     AH,3EH          ;
        INT     21H             ;
        .
        .
        .
```

This code segment implements the essence of the CTTY function of COMMAND.COM, which allows reassignment of the standard console to another device. CTTY allows a user to control this machine remotely using a serial port and modem.

FIGURE 8: *Writing a Control String to PRN*

```
        MOV     CX,3            ;3 bytes to transfer
        MOV     DX,200H         ; from DS:DX
        MOV     BX,0004H        ;  to PRN handle
        MOV     AX,4403H        ;IOCTL write
        INT     21H             ;  via .IOCTL_OUT
        CMP     AX,CX           ;compare requested with actual
        JE      WR_OK           ;
        ;
DS:0200         DB      'E2',0  ;channel string transferred
```

This call sets the serial channel for baud, parity, stopbits, and databits. The HEX value is the channel initialization byte.

FIGURE 9: *Reading a Control String from PRN*

```
        MOV     CX,3            ;3 bytes to transfer
        MOV     DX,300H         ; to DS:DX
        MOV     BX,0004H        ; from PRN handle
        MOV     AX,4402H        ;IOCTL read
        INT     21H             ;  via .IOCTL_IN
        CMP     AX,CX           ;compare requested with actual
        JE      RD_OK           ;
        ;
DS:0300         DB      3 DUP (?)
```

This call reads the last channel initialization byte used to configure the port and compares it to the original.

also apply to block devices. Those that could be used for character devices are found in listing 4, REQHDR.MAC.

The Function Table. Valid function codes range from 0 to 12 for DOS 2.0 and 2.1 and from 0 to 15 for DOS 3.0. The function table contains as many entries as there are function codes. Each entry is the offset address in the code segment to the routine that performs the function requirements.

The entries in the function table of listing 5 are aliases for the actual labels that mark the entry points for the functions in external modules. The macro FUNCTION is used in the device-definition file DD_DEF.MAC to set up the function table. The macro takes the alias label (for example, .INIT) and equates it to the user-defined entry point for the function. If the function is not implemented, any of the labels DONE, INVALID, or DONE2 in ENTRY.ASM could be used as entry points. If the function is implemented, the entry point label is assumed to be external.

If multiple devices are defined in a single file, it may be necessary to create separate function tables for each device. Furthermore, the interrupt entry points in the device headers will have to point to separate set-up code.

Character Driver Function Codes. There are 16 function codes that may be passed to a device driver under DOS 3.0 and 13 under DOS 2.0 and 2.1. Each function code specifies a separate command. In the following descriptions, the names of the commands (for example, .INIT) are labels from the module FUNTBL.ASM. Data placement in the request header is described in terms of offsets that are defined in module REQHDR.MAC.

.INIT (code 0) executes initialization code at installation time. The ending address of the loaded code and/or buffer area that is to remain resident is set by .INIT at offset BRKOFF in the request header. If multiple devices are installed in a single file, the .INIT code for the last device sets the ending address of what will remain resident of the file. DOS does .INIT calls only at installation time, so .INIT code can be discarded by setting the ending address of resident code to .INIT − 1.

Upon entry to .INIT, the 32-bit pointer at offset PARM in the request header points to the ASCII string command line from the DEVICE= command in CONFIG.SYS that installed the device. The command line includes everything that follows the equal sign in the command; it will always include the file name of the installed device driver. A parameter field also may be present after the file name. To determine whether a parameter field is present, scan the command-line string for the first carriage return or line feed. If a line feed is encountered first, no parameter field is present. If a carriage return is encountered first, a parameter field is present and the pointer points one character beyond the end of it.

.IOCTL_IN (code 3), .INPUT (code 4), .OUTPUT (code 8), .VOUTPUT (code 9), and .IOCTL_OUT (code 12) provide actual input and output for the driver. They all use the byte count at offset CNT and the transfer-buffer address at offset BUF in the request header for passing data during the transaction. On return, the actual number of bytes

transferred is posted at offset CNT in the request header. Note that .INPUT, .OUTPUT, and .VOUTPUT deal with the transfer of data on the device channel, whereas .IOCTL_IN and .IOCTL_OUT deal with the transfer of control information to and from the device driver.

.ND_INPUT (code 5) provides nondestructive input without making the calling logic wait. On return, the BUSY bit in the status word is 0 if a character is available in the device buffer and 1 if no character is available. If a character is available, a copy of it is placed in the request block at the offset PRECHAR.

.IN_STAT (code 6) returns status concerning the availability of data on the next read from a character device. Again, the driver sets the BUSY bit in the status word to 0 if data is available and to 1 if no data is available. If the device does not buffer data it should always return the BUSY bit as 0.

.OUT_STAT (code 10) returns a status concerning the device's ability to accept data writes. If the device is busy with a current write request and an .OUTPUT call would be forced to wait, the BUSY bit is set to 1 on return. If the device is available and would act immediately on an output request, the BUSY bit is cleared to 0 on return.

.FLUSHIN (code 7) and .FLUSHOUT (code 11) essentially clear active requests on a device. The device input or output buffer is cleared.

.OPEN (code 13) allows a device to receive initialization or set-up commands at the beginning of an I/O stream. At the end of the I/O stream, the device can be restored to a default set-up or some form of command termination or sign-off can be sent to the device via .CLOSE (code 14).

Functions that a device driver does not support are handled in several ways. For those calls that are unique to block devices, a character device can simply set the DONE bit in the status word and return (that is, exit through DONE in ENTRY.ASM). Even if the device does not support I/O control input strings, nothing prevents calls via DOS function 44H to perform such requests. The appropriate action in this case is to post 0 bytes transferred at offset CNT in the request header, set up the error status and the error code for an unknown command, and then exit. Exiting can be accomplished by transferring control to INVALID in ENTRY.ASM.

If the device does not support I/O control output strings, it is sufficient to exit through DONE in ENTRY.ASM. In this case, the transfer request is to the device driver and the response has the net effect of receiving the control string but not acting on it. Input and output status requests can also be handled by exiting through DONE in ENTRY.ASM. Note that this has the side effect of always returning BUSY as 0.

Three other exit points can be used in order to return from functions. DONE2 sets the DONE and BUSY bits on return from a status function. XFER sets the DONE bit and updates the byte count at offset CNT in the request header by subtracting CX from it. ERROUT sets the DONE and ERROR bits in the status word and uses the contents of AL as an error code.

Device drivers are difficult to debug because once loaded, they are not easily accessed. Bugs in .INIT code can be especially troublesome because they can prevent the system from booting.

Special Considerations. Roughly speaking, if a function module is complicated and requires nested calls to several procedures, it is wise to define a local stack on entry into the module. .INIT code is especially touchy in this regard; it also has other restrictions, which were discussed earlier is this article.

PREPARING A DEVICE DRIVER

Listing 6, MAKE_DD.ASM, contains a number of include files that together provide a generalized front end for any kind of character device driver. The primary include files are DD_MAC.MAC, FUNTBL.ASM, and ENTRY.ASM. The other files contain equates or macros.

Some Rules. MAKE_DD.OBJ is linked with one or more additional modules that implement the driver functions. Listing 7, PRNMOD.ASM, is as an example of such a function module file. User-defined function modules must observe two rules. First, they must use the same code segment declaration that is used at the beginning of MAKE_DD.ASM; second, the externals declared in MAKE_DD.ASM must be satisfied by public declarations in the collection of function modules.

Editing the Device Definition File. Setting up MAKE_DD.ASM for a particular device driver application requires editing only of the file DD_DEF.MAC. The DOS version under which the driver will be used must be specified using an equate: set DOS2_X TRUE for pre-DOS 3.0 and FALSE for DOS 3.0. Set MKNAME to the name of the device driver. The attribute word must be created by making a list of all the bit names that are to be set, separated by the logical OR operator, +. This process ORs together all the named bit constants that were selected and places the resulting value in ATTRIB. Finally, the FUNCTION macro is invoked once for each entry in the function table. If a function is not implemented, the macro takes the following form:

```
FUNCTION FALSE,<function name>,<exit
   point>
```

This macro requires that the exit point be defined in ENTRY.ASM.

Batch Mechanics. Once the function modules have been written and MAKE_DD.ASM has been edited, all that remains to be done is to assemble the program, link it, and convert it to a .COM file. The following batch file handles these steps for the example listing:

```
MASM MAKE_DD,;
MASM PRNMOD,;
LINK MAKE_DD+PRNMOD,PRNDEV;
EXE2BIN PRNDEV.EXE PRNDEV.SYS
```

The link operation will generate a "no stack segment" error, which may be ignored. The LINK command line instructs the linker to produce the file PRNDEV.EXE. In PRNDEV.EXE the device header and the code that follows the header are at an offset of 100H from the beginning of the binary image when the file is loaded. EXE2BIN forces this image into the .COM format, which places the image at an origin of 0000H. The file extension on the output code file written by EXE2BIN has been set to .SYS rather than .COM to indicate that the file is a device driver. To load the new device driver, it is necessary to include the command line

```
device=prndev.sys
```

in the CONFIG.SYS file of the boot drive and then reboot the system.

Some Testing Methodologies. Device drivers are difficult to debug because once loaded, they are not easily accessed. Bugs in .INIT code can be especially troublesome because they can prevent the system from booting. Unless some rather sophisticated debugging tools are available, the safest approach is to start with something that is known to be free of bugs, then add to it in increments.

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For example, use MAKE_DD.ASM with all functions except .INIT exiting through DONE. Within .INIT, perform the minimum requirements of the function—that is, specify the ending address of the driver. If the new device is intended to replace one of the standard devices, the bits in the attribute words for STDIN, STDOUT, and CLOCK should not be set yet and none of the reserved device names should be used; if a reserved device name is used, DOS will open a handle for the device and call it during boot time. An incomplete or malfunctioning driver must *not* replace a necessary standard device, such as the system console.

The lack of standardization of printer-control codes and the great variety of printer capabilities make printer drivers an important bread-and-butter item of systems software consultants.

Now create a loadable device driver, insert an appropriate command line in the CONFIG.SYS file, and reboot the system. At this point the "empty driver" is loaded; its location in memory can be determined by opening an FCB for the device name. The sample DEBUG session that is shown in figure 5 illustrates the method. From the header, according to this figure, the strategy entry point is 085F:0036 and the interrupt entry point is 085F:0041. A standard FCB was used in this case and the offset to the device header pointer depends upon the DOS version. DOS 3.0 is shown in the example. The offset for DOS 2.X is 19H from the beginning of the FCB buffer.

The safe way to proceed would be to add the function modules at this point, reload the device driver, and test each function by direct calls. For example, to test the .IOCTL_IN function in PRNMOD.ASM, the debug session might proceed as shown in figure 6.

.INIT code can be traced cheaply using some HEX dump routines that display contents of memory locations or registers at the console. During the debug stages, use a local stack to prevent crashes caused by clobbering the stack of IBMBIO's device-installation routine. Envelop the trace routines and calls in conditional assembly brackets:

```
if DEBUG
mov ax,bx
call DISP16
endif
```

so that changing a single equate pulls all of the trace stuff out.

A device can be accessed from within an applications program in two ways. The preferred method is to make a DOS call that in turn sets up one or more appropriate request headers and strategy and interrupt calls. The other method, sometimes used as a debugging aid, is to make a request header and call the device driver directly. The latter method requires the program to provide the error-handling routines that DOS provides if system calls are used. It has the advantage, however, of giving more direct control of a device and providing the possibility of using the .INIT function (assuming it is resident) for purposes other than installation.

If the DOS interface is used, it is necessary to open an FCB or file handle for any device other than the standard I/O devices. For example, the code segment that is reproduced in figure 7 implements the essence of the CTTY function of COMMAND.COM, which permits reassignment of the standard console to another device.

Figures 8 and 9 illustrate the use of I/O control strings in setting or interrogating a device, in this case the PRN device developed as an example driver. The call in figure 8 sets the serial channel for baud, parity, stopbits, and databits. The HEX value written is used as the channel initialization byte. The call in figure 9 reads the last channel initialization byte used to configure the port.

These IOCTL examples are based on a simple device driver. A more useful driver would include selectable escape sequences for setting various kinds of forms, character fonts, and graphics modes. The lack of standardization of printer-control codes and the great variety of printer capabilities make printer drivers an important bread-and-butter item of systems software consultants. The "boilerplate" character driver presented in this article should make it easier to get a piece of that action—or at least it will be enough to force that old Diablo in the corner to get on speaking terms with your PC.

Stan Mitchell is a software engineer at Sysgen, Inc., in Fremont, California. He has a master's degree in geology.

iscontinued

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PC WEEK

FEBRUARY 5, 1985
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LISTING 1: DD_MAC.MAC

```
;
;       Initialize 8 Constants for Character Device Name to ' '
;
IN_NAME  MACRO
X        =      0
         REPT   8
X        =      X+1
         CHARSP %X
         ENDM
         ENDM
;
;        Assign each letter of Character Device Name
;          to a Constant
;
MKNAME   MACRO  NLIST
X        =      0
         IRPC   M,NLIST
X        =      X+1
         CHAREQU    %X,M
         ENDM
         ENDM
;
;        Assign Constant the ASCII value of Z
;
CHAREQU  MACRO  Y,Z
N&Y      =      '&Z'
         ENDM
;
;        Assign Constant an ASCII value of ' '
;
CHARSP   MACRO  Y
N&Y      =      ' '
         ENDM
;
;        Convert ASCII Constants to String of DB's
;
DDNAME   MACRO
X        =      0
         REPT   8
X        =      X+1
         CHARDB  %X
         ENDM
         ENDM
;
;        Convert an ASCII Constant to a DB
;
CHARDB  MACRO  Y
         DB     N&Y
         ENDM
;
;        Define a Device Header Structure
;
DEVHDR   MACRO  NXTOFF,NXTSEG,ATTRIB,STRAT,INTRPT
         DW     NXTOFF
         DW     NXTSEG
         DW     ATTRIB
         DW     STRAT
         DW     INTRPT
         DDNAME
         ENDM
;
;        DEF = TRUE if the function is implemented
;        NAME = name of the function
;        ENTRY = label of the function entry point
;                or exit point if not implemented
;
FUNCTION   MACRO   DEF,NAME,ENTRY
         ;
         _&NAME EQU     DEF
         IF   _&NAME
              IFNDEF  ENTRY
               EXTRN   ENTRY:near
              ENDIF
         ENDIF
         .&NAME EQU     ENTRY
         ENDM
```

LISTING 2: DD_DEF.MAC

```
;************************************************************
;
;                    DEVICE DEFINITION FILE
;
;************************************************************
;
TRUE     EQU    1
FALSE    EQU    0
;
;        Initialize Device Name to Blanks
IN_NAME
;************************************************************
; Select DOS version number:
;        for DOS 2.00 or 2.10 set DOS2_X to TRUE
;        for DOS 3.00 set DOS2_X to FALSE
;
DOS2_X   EQU    FALSE
DOS3_0   EQU    NOT DOS2_X
;
;************************************************************
; Enter device driver name here in place of X's
;        (1 to 8 characters in upper case)
;
;MKNAME   XXXXXXXX
 MKNAME   PRN
;
;************************************************************
;
;       Select attributes for device from the following table:
;
;       Defined Attribute Bits
;
CHR      EQU    8000H              ;character device
IOCTL    EQU    4000H              ;IOCTL supported
IBM      EQU    2000H              ;IBM format block device
;
         if     DOS3_0
OCREM    EQU    0800H              ;open, close, &
                                   ;  removable media support
         endif
;
SPECIAL  EQU    0010H              ;special device
                                   ;  using INT 29H handler
CLOCK    EQU    0008H              ;current clock device
NUL      EQU    0004H              ;current NUL device
STDOUT   EQU    0002H              ;current standard output device
STDIN    EQU    0001H              ;current standard input device
;
;    Example:  CHR+SPECIAL+STDOUT+STDIN
;              defines a console device attribute word of 8013H
;
;************************************************************
; Edit this line to define your attribute:
;
ATTRIB   EQU    CHR+IOCTL
;
;************************************************************
         PAGE
;************************************************************
;
; Each line in the following table contains 3 arguments:
;
; #1 is TRUE if the function is implemented, FALSE if not
; #2 is the name of a valid function to which
;    the TRUE or FALSE applies
; #3 is the label which is the entry point for this function;
;    if the function is not implemented, DONE or INVALID will
;    be used; also note that if the function is implemented
;    the MACRO declares the label EXTRN. If the function is
;    not implemented the exit pt. is assumed to be defined
;    within ENTRY.ASM.
;
FUNCTION  TRUE,INIT,PRNIT
FUNCTION  FALSE,MEDIA_CHECK,DONE
FUNCTION  FALSE,BUILD_BPB,DONE
FUNCTION  TRUE,IOCTL_IN,PRNCTL_IN
FUNCTION  FALSE,INPUT,XFER
FUNCTION  FALSE,ND_INPUT,DONE2
FUNCTION  FALSE,IN_STAT,DONE
FUNCTION  FALSE,FLUSHIN,DONE
FUNCTION  TRUE,OUTPUT,PRNOUT
FUNCTION  TRUE,VOUTPUT,PRNOUT
FUNCTION  TRUE,OUT_STAT,PRNSTAT
FUNCTION  FALSE,FLUSHOUT,DONE
```

```
FUNCTION  TRUE,IOCTL_OUT,PRNCTL_OUT
          if    DOS3_0
FUNCTION  FALSE,OPEN,DONE
FUNCTION  FALSE,CLOSE,DONE
FUNCTION  FALSE,REMOVABLE,DONE
          endif
;
;End of device definition file
;-----------------------------------------------------------
```

LISTING 3: ENTRY.ASM

```
          PUBLIC REQHDR,DONE,INVALID,DONE2,ERROUT,XFER
;
;request header pointer
;
REQHDR    LABEL  DWORD
REQHDRo   DW     ?        ;offset
REQHDRs   DW     ?        ;segment
;
;         Strategy Entry Point
;
STRAT_ENT:
          MOV    CS:REQHDRo,BX   ;save off of request header ptr
          MOV    CS:REQHDRs,ES   ;save seg of request header ptr
          RET                    ;far return
;
;         "Interrupt" Entry Point
;
;          Note: DOS's stack allows saving registers
;          but if your routines need more stack space than
;          that, it will be necessary to define a local stack.
;
INT_ENT:
          PUSHF                  ;preserve flags
          CLD                    ;set up frwrd string operations
          PUSH   SI              ;preserve registers
          PUSH   AX              ;
          PUSH   CX              ;
          PUSH   DX              ;
          PUSH   DI              ;
          PUSH   BP              ;
          PUSH   DS              ;
          PUSH   ES              ;
          PUSH   BX              ;
;
          LDS    BX,CS:REQHDR      ;DS:BX pts to request header
          MOV    CX,[BX+CNT]       ;get byte count
          MOV    AL,[BX+CMD]       ;get command code
          CMP    AL,HIFUNC         ;check for invalid cmd. code
          JA     INVALID           ;
          XOR    AH,AH             ;
          ROL    AL,1              ;convert to offset
          LEA    SI,FUNTBL         ;set up ptr to function table
          ADD    SI,AX             ;select table entry
          LES    DI,DWORD PTR [BX+BUF]   ;get buffer addr. ES:DI
          PUSH   CS                ;
          POP    DS                ;dest. addr = DS:SI
          JMP    WORD PTR [SI]     ;   and jump to it
;
INVALID:  MOV    AL,UNKCMD           ;unknown command error
          SUB    [BX+CNT],CX         ;zero bytes transferred
ERROUT:   MOV    AH,ERROR+REQDON     ;set error & done bits
          JMP    SHORT   EXIT        ;
;
DONE2:    MOV    AH,REQDON+BUSY      ;set done+busy bits in
                                     ;request header status byte
          JMP    SHORT   EXIT        ;
;
XFER:     LDS    BX,CS:REQHDR        ;
          SUB    [BX+CNT],CX         ;return # of bytes xferred
DONE:     MOV    AH,REQDON           ;set done bit in request
                                     ;header status byte
EXIT:     LDS    BX,CS:REQHDR        ;
          MOV    [BX+STAT],AX        ;request header status
;
          POP    BX                  ;restore registers
          POP    ES                  ;
          POP    DS                  ;
          POP    BP                  ;
          POP    DI                  ;
          POP    DX                  ;
          POP    CX                  ;
          POP    AX                  ;
          POP    SI                  ;
          POPF                       ;
          RET                        ;far return
;
```

LISTING 4: REQHDR.MAC

```
;
;
; static request header
LNG       EQU    0         ;BYTE: first byte is length
                           ;  of header
UNIT      EQU    1         ;BYTE: unit number
                           ;  for block devices
CMD       EQU    2         ;BYTE: command code for request
STAT      EQU    3         ;WORD: status
DOS_Q     EQU    5         ;DWORD: DOS queue
DEV_Q     EQU    9         ;DWORD: device queue
;
; init header
UNITS     EQU    13        ;BYTE: number of units
BRKOFF    EQU    14        ;DWORD: ending address
                           ;  for resident code
BRKSEG    EQU    16        ;
BPB       EQU    18        ;DWORD: ptr to BPB array
                           ;  on exit (block devices only)
PARMS     EQU    18        ;DWORD: ptr to string following
                           ;  "device=" cmd
;
; non destructive read - no wait
PRECHAR   EQU    13        ;BYTE: one look ahead character
;
; input, output, IOCTL in, IOCTL out
MEDIA     EQU    13        ;BYTE: media descriptor byte
BUF       EQU    14        ;DWORD: buffer address
CNT       EQU    18        ;WORD: byte/sector count
START     EQU    20        ;WORD: starting sector number
;
;  status word bit definitions (most significant byte)
;
REQDON    EQU    01H       ;request complete
BUSY      EQU    02H       ;device busy
ERROR     EQU    80H       ;error encountered
;
;  status word error codes (least significant byte)
;
NOTRDY    EQU    02H       ;device not ready
UNKCMD    EQU    03H       ;unknown command
NOPAPER   EQU    09H       ;printer out of paper
WRFLT     EQU    0AH       ;write fault
RDFLT     EQU    0BH       ;read fault
FAIL      EQU    0CH       ;general failure
```

LISTING 5: FUNTBL.ASM

```
;
;function table
;
FUNTBL    LABEL  BYTE      ;code    function
                            ****    ************************
;
     DW     .INIT          ; 0      initialization
     DW     .MEDIA_CHECK   ; 1      media check (block only)
     DW     .BUILD_BPB     ; 2      build BPB (block only)
     DW     .IOCTL_IN      ; 3      IOCTL input
     DW     .INPUT         ; 4      input from device
     DW     .ND_INPUT      ; 5      non-destructive input
     DW     .IN_STAT       ; 6      input status
     DW     .FLUSHIN       ; 7      input flush
     DW     .OUTPUT        ; 8      output to device
     DW     .VOUTPUT       ; 9      output (with verify)
     DW     .OUT_STAT      ; 10     output status
     DW     .FLUSHOUT      ; 11     output flush
     DW     .IOCTL_OUT     ; 12     IOCTL output
;
          if    DOS3_0
HIFUNC    EQU   15
     DW     .OPEN          ; 13     open device
     DW     .CLOSE         ; 14     close device
     DW     .REMOVABLE     ; 15     removable media check
                           ;        (block devices only)
          else
HIFUNC    EQU   12
          endif
;
```

LISTING 6: MAKE_DD.ASM

```
        PAGE
        PAGE    62,132
        TITLE   Device Driver Construction Program
        NAME    make_dd
;---------------------------------------------------------------
;
CSEG    SEGMENT PARA PUBLIC 'CODE'
        ASSUME  CS:CSEG,DS:CSEG
;
;
DDRIVER  PROC   FAR
        ;
        ;
BEGIN:
START   EQU     $
;---------------------------------------------------------------
        INCLUDE         DD_MAC.MAC
        PAGE
        INCLUDE         REQHDR.MAC
        PAGE
        INCLUDE         DD_DEF.MAC
        PAGE
        INCLUDE         DEVHDR.ASM
        PAGE
        INCLUDE         FUNTBL.ASM
        PAGE
        INCLUDE         ENTRY.ASM
;---------------------------------------------------------------
DDRIVER ENDP
CSEG    ENDS
;
        END     BEGIN
;---------------------------------------------------------------
```

LISTING 7: PRNMOD.ASM

```
        PAGE
        PAGE    62,132
        TITLE   RS232 Printer Device Driver Module
        NAME    prnmod
        ;
        INCLUDE     REQHDR.MAC
        ;
CSEG    SEGMENT PARA PUBLIC 'CODE'
        ASSUME  CS:CSEG, DS:CSEG
        ;
        ;Defined elsewhere...
        EXTRN   DONE:near, DONE2:near, ERROUT:near, XFER:near
        EXTRN   REQHDR:dword
        ;
        ;Defined here...
        PUBLIC  PRNOUT, PRNSTAT, PRNIT
        PUBLIC  PRNCTL_IN, PRNCTL_OUT
        ;
;
;       RS232 Communications channels
COMM0   EQU     0
COMM1   EQU     1
;
;       Interrupt 14H functions                                  *
SETCOMM EQU     0       ;set channel baud,parity,
                        ;stopbits,databits
WRITE   EQU     1       ;write AL to port
READ    EQU     2       ;read AL from port
STAT    EQU     3       ;read channel status
;
;       Returned status bits
TXEMPTY EQU     20H     ;transmitter register empty
DSRBIT  EQU     20H     ;data set ready bit
CTSBIT  EQU     10H     ;clear to send bit
TX_OK   EQU     80H     ;transmission successful
;
;       Channel initialization byte
;          Bit field definitions
B110    EQU     00000000B       ;110 BAUD
B150    EQU     00100000B       ;150 BAUD
B300    EQU     01000000B       ;300 BAUD
B600    EQU     01100000B       ;600 BAUD
B1200   EQU     10000000B       ;1200 BAUD
B2400   EQU     10100000B       ;2400 BAUD
B4800   EQU     11000000B       ;4800 BAUD
B9600   EQU     11100000B       ;9600 BAUD
;
NOPAR   EQU     00000000B       ;no parity
ODD     EQU     00001000B       ;odd parity
EVENP   EQU     00011000B       ;even parity
;
STOP1   EQU     00000000B       ;1 stop bit
STOP2   EQU     00000100B       ;2 stop bits
;
DATA7   EQU     00000010B       ;7 bits data
DATA8   EQU     00000011B       ;8 bits data
;
DEFAULT EQU     B9600+EVENP+STOP1+DATA7
        page
;---------------------------------------------------------------
;
;       .OUTPUT: Printer Output via ROM BIOS INT 14H
;                                                              *
;       On entry  DS=CS, CX=byte count, ES:DI transfer buffer
;
PRNOUT  PROC    NEAR
        ;
        JCXZ    OEX             ;if 0 bytes to xfer, return
NXBYTE: MOV     AL,ES:[DI]      ;get byte from transfer buffer
        INC     DI              ; advance buffer ptr
        MOV     BYTE PTR RCNT,2
        ;
RETRY:  MOV     AH,WRITE        ;send AL to COMMO port
        MOV     DX,COMM1        ;
        INT     14H             ;
        TEST    AH,TX_OK        ;transmission successful?
        JZ      CONTINUE        ;   then continue
        ;
        DEC     BYTE PTR RCNT   ;decrement retry count
        JNZ     RETRY           ;
        MOV     AL,WRFLT        ;write fault error code
        JMP     ERROUT          ;  exit
        ;
CONTINUE:
        LOOP    NXBYTE          ;exhaust byte count
OEX:    JMP     DONE            ;successful return
        ;
PRNOUT  ENDP
;
RCNT    DB      ?               ;error retry count
;
        page
;---------------------------------------------------------------*
;
; .IOCTL_IN: Read printer channel initialization parameter
;
;    On entry  DS=CS, CX=byte count, ES:DI transfer buffer
;
PRNCTL_IN  PROC   NEAR
        ;
        JCXZ    OEX             ;leave if 0 bytes requested
        MOV     SI,OFFSET DEST  ;
        ;
RDPARM: MOV     AL,[SI]         ;move parameters
                                ;  to transfer buffer
        MOV     ES:[DI],AL      ;  with 0 termination
        OR      AL,AL           ;
        JZ      MOVFIN          ;
        INC     SI              ;
        INC     DI              ;
        LOOP    RDPARM          ;
        INC     CX              ;
        ;
MOVFIN: DEC     CX              ;
        JMP     XFER            ;on return set DONE
                                ;and bytes transferred
        ;
PRNCTL_IN  ENDP
        page
;---------------------------------------------------------------*
;
; .IOCTL_OUT: Write printer channel initialization parameter
;
;    On entry  DS=CS, CX=byte count, ES:DI transfer buffer
;
PRNCTL_OUT  PROC   NEAR
        ;
```

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QICSTOR-PLUS. The ultimate in PC expansion with five IBM compatible slots, hard disk storage, and streaming tape backup in one neat package.

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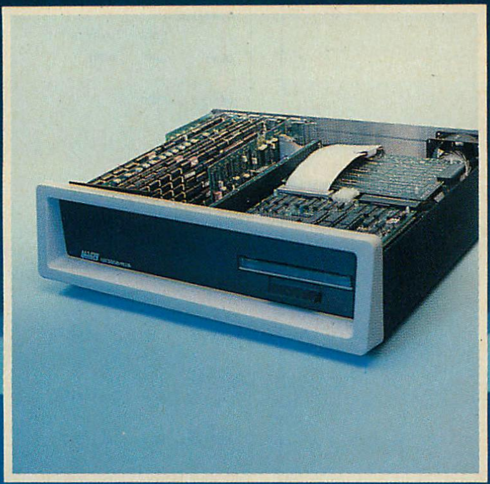

COMDEX/Spring '85

ALLOY
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CIRCLE NO. 111 ON READER SERVICE CARD

```
        JCXZ    OEX             ;leave if 0 bytes requested
        MOV     SI,OFFSET DEST  ;
        CMP     CX,20           ;if request is to send > 20
        JBE     WRPARM          ;  bytes, set limit at 20
        MOV     CX,20           ;
        ;
WRPARM: MOV     AL,ES:[DI]      ;move parameters
                                ;  from transfer buffer
        MOV     [SI],AL         ;
        INC     SI              ;
        INC     DI              ;
        LOOP    WRPARM          ;
        ;
        PUSH    CX              ;
        CALL    CH_BYTE         ;convert first 2 characters
                                ;  to byte
        MOV     AH,SETCOMM      ;initialize channel
        MOV     DX,COMM1        ;  to requested baud rate,
                                ;  parity, etc.
        INT     14H             ;
        POP     CX              ;
        ;
        JMP     XFER            ;on return set DONE
                                ;  and bytes transferred
        ;
PRNCTL_OUT  ENDP
;
;       Channel initialization byte
OLDPARM  DB     DEFAULT         ;default 9600,even parity,
                                ;  7 data, 1 stop bit
        page
;------------------------------------------------------------
;
;   .OUTSTAT: Printer channel status from ROM BIOS INT 14H
;
;    On entry  DS=CS, CX=byte count, ES:DI transfer buffer
;
PRNSTAT  PROC   NEAR
        ;
        MOV     AH,STAT         ;get channel status in AX
        MOV     DX,COMM1        ;
        INT     14H             ;
        ;
        ;check that CTS and DSR are asserted
        TEST    AL,CTSBIT+DSRBIT
        JZ      BSY             ;
        TEST    AH,TXEMPTY      ;transmitter register empty?
        JZ      BSY             ;
EXIT:   JMP     DONE            ;NOT busy return
BSY:    JMP     DONE2           ;busy return
        ;
PRNSTAT  ENDP
;
;
;   Convert ASCII HEX comm port initialization byte to binary
;
CH_BYTE  PROC   NEAR
        ;
        PUSH    CS              ;
        POP     DS              ;
        MOV     BX,OFFSET DEST  ;point to parameter string
        MOV     AL,[BX+0]       ;get most significant HEX digit
        CALL    TOHEX           ;  convert to binary nibble
        XCHG    AL,AH           ;  save in AH
        MOV     AL,[BX+1]       ;get least significant HEX digit
        CALL    TOHEX           ;convert to binary nibble in AL
        MOV     CL,4            ;
        SHL     AH,CL           ;shift most significant digit
                                ;  into upper nibble
        ADD     AL,AH           ;combine with lower nibble
                                ;  and save
        MOV     BYTE PTR OLDPARM,AL
        RET                     ;
CH_BYTE  ENDP
;
;       Convert ASCII HEX byte to binary byte
;
TOHEX    PROC   NEAR
        ;
        SUB     AL,30H          ;
        CMP     AL,0AH          ;
        JC      HEXRET          ;
        SUB     AL,07H          ;
```

```
HEXRET: RET                     ;
        ;
TOHEX   ENDP
;
;------------------------------------------------------------
;
;       .INIT: PRN device driver INIT code
;
;       On entry  DS=CS, CX=byte count, ES:DI transfer buffer
;
CR      EQU     0DH
LF      EQU     0AH
DESTLNG EQU     20
;
;       Parameters passed in device= command line
DEST    DB      DESTLNG  DUP (?)
;
;
PRNIT   PROC    NEAR
        ;
ENDPRN  EQU     $
        ;
        LEA     AX,CS:ENDPRN    ;offset to end
                                ;  of resident driver
        MOV     DX,CS           ;segment address
        LDS     BX,CS:REQHDR    ;DS:BX pts to request header
        MOV     [BX+BRKSEG],DX  ;save ending code seg address
        MOV     [BX+BRKOFF],AX  ;save ending code offs address
        ;
        ;get ptr to filename portion of command line
        ;  in CONFIG.SYS file
        LDS     SI,DWORD PTR[BX+PARMS]
        PUSH    CS              ;
        POP     ES              ;
        MOV     DI,OFFSET DEST  ;destination address for parms
        ;
TOP1:   MOV     AL,[SI]         ; check for termination char's
        ;
        ;command line has the form: device=filename /parms<CR>
        ;                 or       device=filename<LF>
        ;
        CMP     AL,CR           ;parms are present
        JZ      GETPARMS        ;
        CMP     AL,LF           ;no parm field
        JZ      NOPARMS         ;
        ;
        INC     SI              ;
        JMP     SHORT TOP1      ;
        ;
GETPARMS:
        MOV     CX,0            ;character count
NXTCHR: DEC     SI              ;back up ptr
        INC     CX              ;
        MOV     AL,[SI]         ;
        CMP     AL,'/'          ;scan for start character
        JNZ     NXTCHR          ;
        DEC     CX              ;
        INC     SI              ;ready to move parms to DEST
        REP     MOVSB           ;
        MOV     AL,0            ;terminate with 0
        MOV     ES:[DI],AL      ;
        CALL    CH_BYTE         ;convert parm to binary byte
                                ;  in OLDPARM
NOPARMS:
        MOV     AL,BYTE PTR OLDPARM
        MOV     AH,SETCOMM      ;initialize channel
        MOV     DX,COMM1        ;  to requested baud rate,
                                ;  parity, etc.
        INT     14H             ;
        ;
        MOV     DX,OFFSET SIGN_ON
        MOV     AH,9            ;boot message
        INT     21H             ;
        JMP     DONE            ;
        ;
PRNIT   ENDP
;
SIGN_ON DB      'Serial printer channel 1 initialized'
        DB      0AH,0DH,'$'
;
CSEG    ENDS
        END
```

Introducing

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Complete with tape drive, controller, and software

And it works easily with all IBM compatible operating systems. Simply tell your tape drive you want to backup or restore the entire hard disk, or any file, or backup or restore by subdirectory, date, or everything since you last backed up.

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Let's face it, we've all heard the horror stories of people who've lost data on their hard disk. True, it doesn't happen often, but then disaster seldom does. With the amount of data you can put on a hard disk these days, no one in business can afford even a small disaster.

When did you last backup your hard disk?

Oh, you did it once with floppies and it was so time consuming that now you've convinced yourself nothing will go wrong? In other words, it can't happen to you. And besides, at the prices they're asking for tape backup—$2,000 and up—you're willing to take a chance. You've seen some tape drives for less, but you have to buy an expensive hard disk to go with it, and you've already got a good hard disk. Where can you turn for relief?

IBM Compatible tape drive system complete for $995

The Express Systems™ tape drive comes complete—half-high tape drive, controller, and software—for only $995. It's absolutely IBM compatible—all 60 megabytes of it.

You can use your tape drive in the event your hard disk fails. And if you have to replace your hard disk, the tape's ability to read bad sectors will let you replace your hard disk with another even if the new one is not error-free. The tape requires very low power, too.

And it doesn't poke along. It reads and writes at 90 inches per second (ips) and transfers data at up to 3.75 megabytes per minute in the streaming mode. You don't have to be a rocket scientist to figure that you can perform an image backup of a 20 megabyte hard disk in about 5 minutes. But practically speaking, once you back up your hard disk completely for the first time, you never need to do more than invoke the archive command—that convenient command that tells your new tape drive to back up everything since you last backed up. If you backup as often as you should, your Express Systems tape drive will finish the job virtually in seconds.

The Express Systems software has additional benefits, like enabling you to use PC DOS terminology such as "*", "*.*", and "?". It also has a built-in reformatter, built-in verification (to make sure you transferred what you thought you did), and it's prompt driven, which means it asks you exactly what you want to do.

Easy to install

Before you get intimidated about installing our tape drive internally, you should understand that IBM doesn't think it's too difficult. They're selling IBM PC ATs with instructions on how to add additional hard disks in the *Installation and Setup* manual that comes with the AT.

The IBM AT installation manual shows how easily you can install internal storage drives yourself.

Our instructions for installin[g] your new Express Systems tap[e] drive follow IBM's clear, simpl[e] instructions.

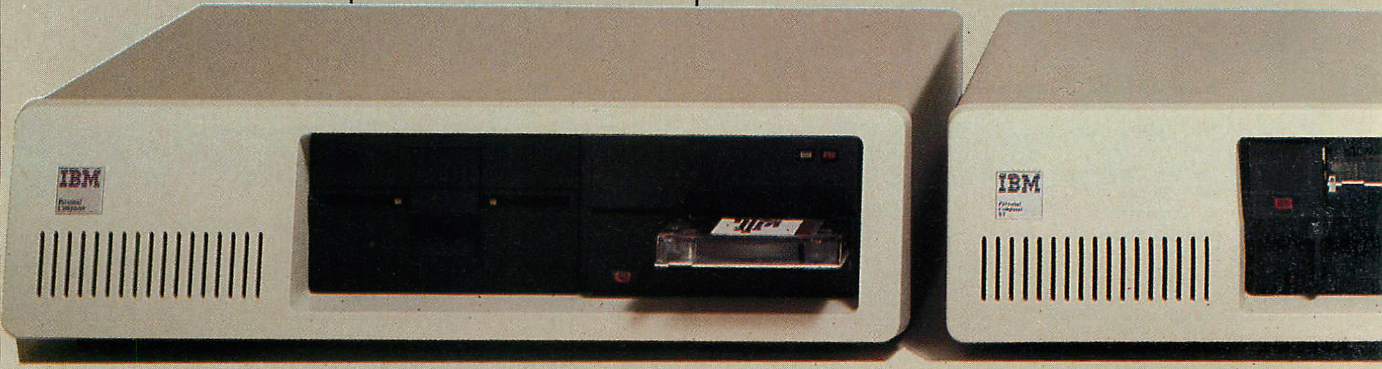
We even provide the tape cartridge

Most people don't realize tha[t] the tape cartridge contains mos[t] of the critical mechanisms to in[-] sure data integrity. In order t[o] be sure that you get the best in[-] surance for your data (after all[,] isn't that why you're buying it[)] we encourage you to use Ex[-] press Systems' specially teste[d] tape cartridges. We're not goin[g] to kid you and tell you other[s] won't work, but here's what'[s] special about Express Systems tape cartridges.

First, they are tested dow[n] four separate tracks from end[-] to-end, not just down the cente[r] of the first 150 feet, like som[e] others do. We use three screw[s] to hold the cover on instead o[f] four. This simple triangula[r] arrangement keeps the base[-] plate flat, just like three leg[s] work better than four to make [a] table steady. Since all tap[e] drives reference everything t[o] the base-plate, this alignment is critical. We also use special rollers to dissipate posible static electricity buildup—something that can ruin your whole day.

The Express Systems tape drives come with Express Certified™ 555 or 600 ¼-inch tape cartridges with quadruple end-to-end testing for extra insurance of your data.

And finally, we will sell yo[u] tape cartridges in boxes of thre[e] instead of the usual five. So, yo[u] get higher quality with a smalle[r] quantity commit[-] ment. And w[e] compound the sav[-] ings with a lowe[r] per unit price, jus[t] $35.00 instead o[f] the usual $45.0[0] most retailer[s] charge.



Need a hard disk?

Depending on whether you have an IBM PC, XT, or AT you may want additional hard disk storage. We have those too. We offer 10, 21 and 31 megabytes of formatted hard disk storage.

For the most part, our drives are made with plated media, which means there is less chance to damage them. (Let's face it, the oxide that most disks come with is nothing more than rust.) We then test the drives, pre-format them, and install DOS 3.0 so that you're ready to begin transferring files. We even include DOS 3.0 documentation.

Express Systems offers 10, 21, and 31 megabytes of formatted storage in the half-high form so you have extra space for other storage options.

And they're 100 percent IBM compatible. The controller we send you for the XT is an upgraded version of the XT controller from the same company that makes the XT controller. In fact, the Express Systems controller is an improved controller which requires less power so that it is more reliable than any other standard controller.

We provide the power too.

If you want to upgrade your IBM PC, there just isn't any way around upgrading your power supply—if you want to have true XT or better capability. Some companies say that their hard disks don't require any increase in power—and they might be right. But don't add anything to your slots, because the minute you do, you'll need more power. That's the bad news.

Our 130 watt power will convert your PC to XT standards; and it's only $99.50 with any tape drive or hard disk order.

The good news is that our power supplies are inexpensive. How's $99.50 for an XT power supply? We mean a full 130 watts of power. The other good news is that it's held in by only 4 screws. Express Systems' power supplies can be changed in 20 minutes, a small price in time for the peace of mind to convert your PC to an XT-capable machine and avoid the unsightly "wart-like" power supply add-ons that some companies insist you paste on the back of your PC.

Express Systems Upgrade Kits

(Includes controller, software, and cable where appropriate)

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1 half-high tape drive system	**$995**
IBM XT to XT ExPlus	
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IBM AT (model 68) to AT ExPlus	
21 Megabyte upgrade 1 half-high 21 megabyte hard disk with half-high tape drive system	**$1895**
31 Megabyte upgrade 1 half-high 31 megabyte hard disk with half-high tape drive system	**$2195**
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2 half-high floppies, 1 half-high 10 megabyte hard disk with controller, 1 half-high tape drive system and 130 watt power supply	**$2095**

But from a mail order house?

We get tired of the snide remarks some people make about mail order houses. The comments are usually spread by distributors and retailers who are getting cut out of 15 and 35 percent margins, respectively. If we went through distribution—you'd have the privilege of paying for large glass windows, rugs, salesmen, etc.—but we'd also be selling this tape drive for $1495.

We're not criticizing distributors and retailers. They perform a valuable service. But you don't need them if you know what you want. And you can certainly install it yourself. IBM has proved it with their instructions for self-installation that come with the new IBM PC AT.

And speaking of IBM, the next time you hear anyone criticize mail order as a way to buy computer equipment, remind them that IBM is now in the mail order business.

Warranty

We offer you a one year warranty on our hard disks—the same as IBM on the AT and 90 days on the tape drives. (It's all the manufacturer gives us.) If anything goes wrong with your tape or disk drive or hard disk, send it back in the box it came in. However, we have found that we can usually solve the problem over the phone. So call first for a return authorization number because we can't accept any returns without it.

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We have four types of delivery: *Next Flight Out*℠ if you need it immediately: *Next Day Express*℠ and *Day After Tomorrow*℠ if you can wait a day or two; and our normal delivery—which we pay—if you can wait a few days.

Express Systems Product Line

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Hard disk controller	**$195**
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130 Watt XT replacement Power Supply	**$99.50**
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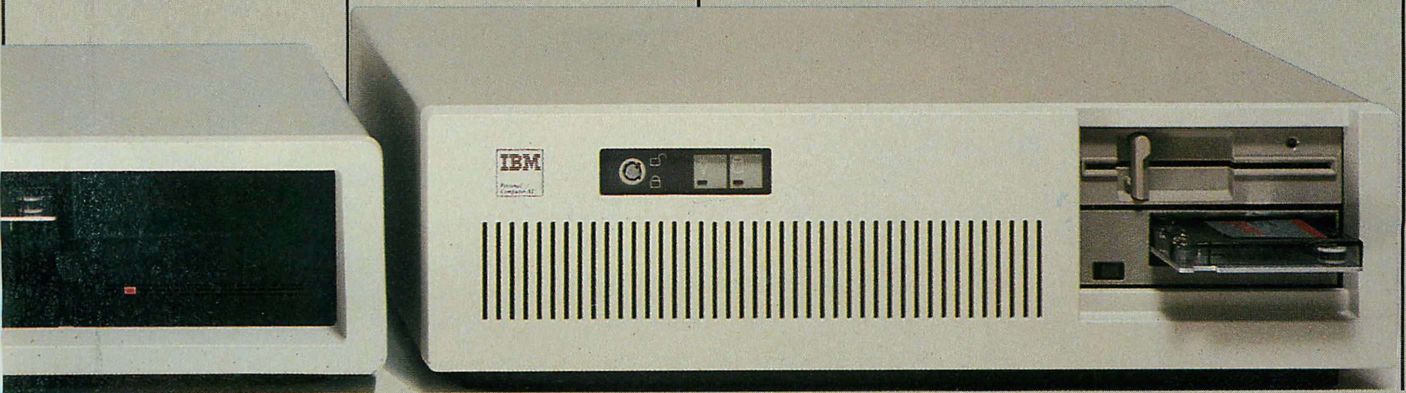
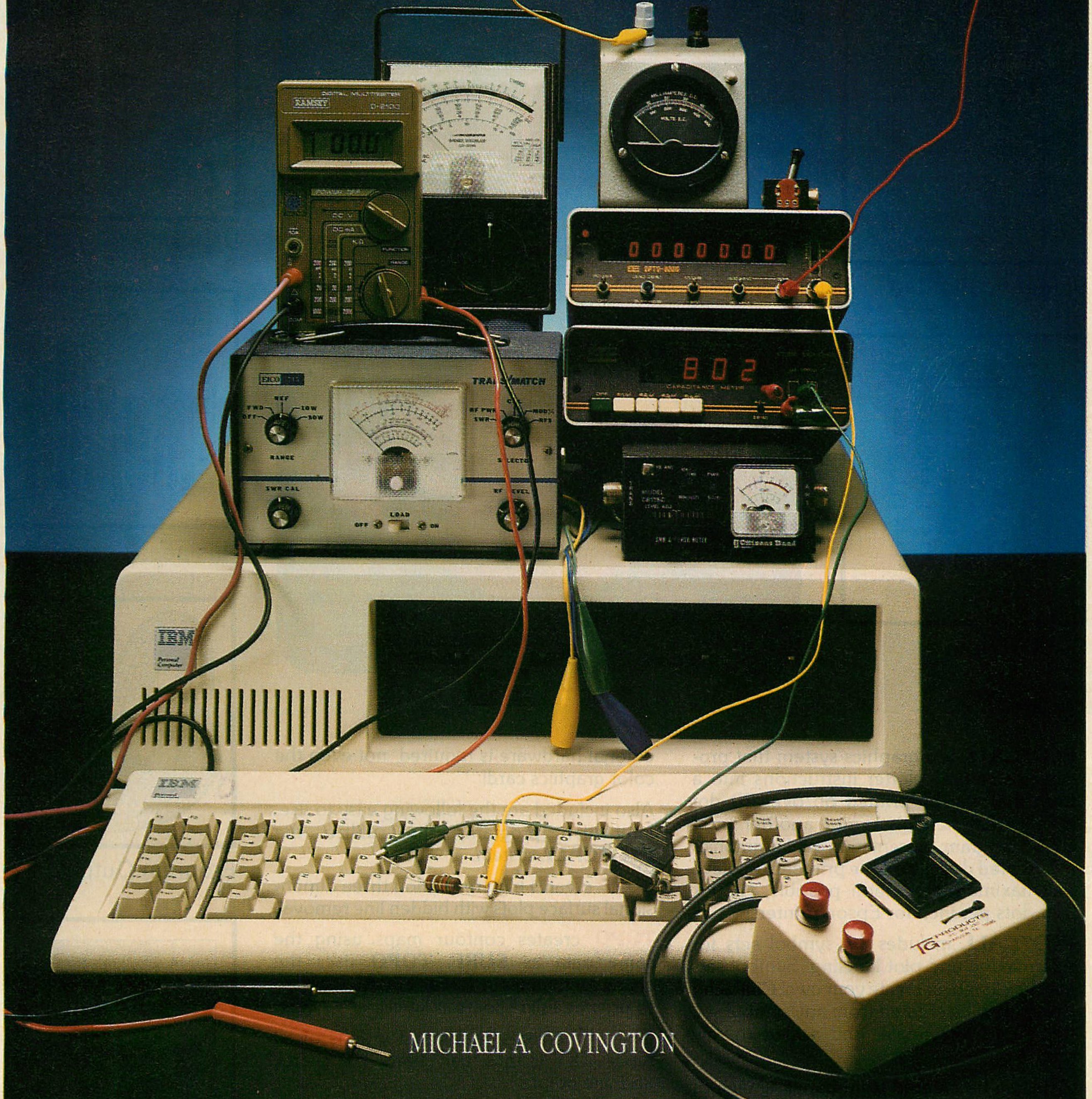


Joystick Metrics

Measuring physical properties through the PC's joystick port



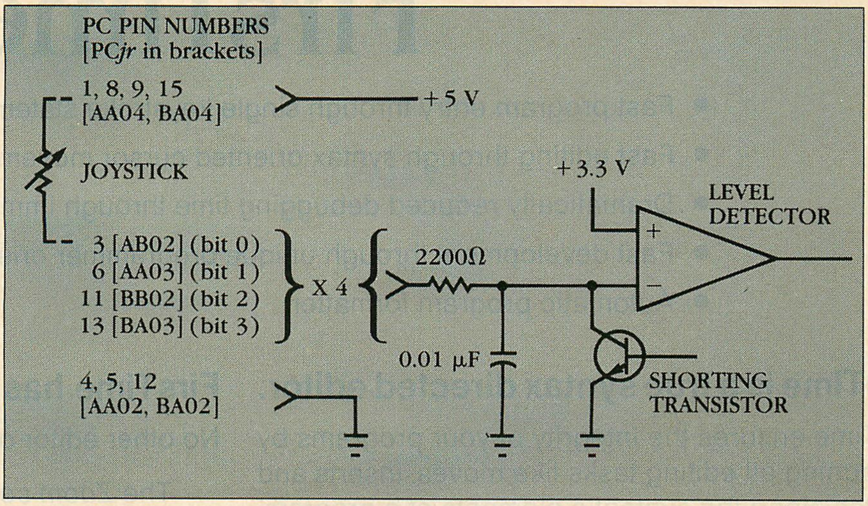
MICHAEL A. COVINGTON

The IBM PC is put to some of its most interesting applications when it is asked to handle data on and respond to external physical conditions. Microcomputers can serve in many such capacities: as superintelligent thermostats for heating systems, data collection devices for the laboratory, or automated troubleshooters for electronic equipment. In addition, unlike other kinds of measuring equipment, the computer can store and analyze large amounts of data automatically.

Almost all of these applications require some form of analog-to-digital conversion—that is, a continuously varying quantity, such as a voltage, has to be converted into computer-readable form. Commercial analog-to-digital converters often cost hundreds of dollars, but the PC's joystick port (officially called the IBM Game Control Adapter) can be used to do the same job in a simpler way. The circuits discussed in this article can convert the joystick port into a device that will measure resistance, capacitance, or voltage. No modification to the PC or the adapt-

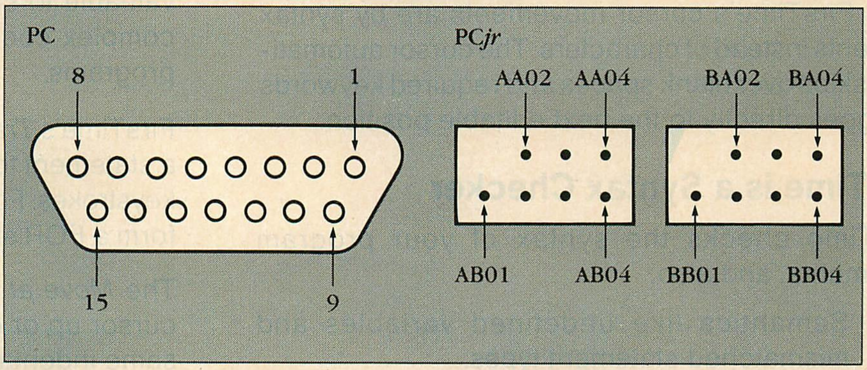
PHOTOGRAPH • MARC DAVID COHEN

FIGURE 1: *Joystick Port Circuit (Simplified)*



The joystick position is read by moving the short circuit across the capacitor and measuring the time required for it to charge to about 3.3 volts.

FIGURE 2: *Joystick Port Pin Connections*



On the PC and PCjr, pins are numbered as seen by looking at the joystick socket from outside the computer. On the PC, pin numbers are usually shown on the connector. On the PCjr (at right), AA01 and BA01 are the missing pins.

er is required: the circuits all plug in externally in place of the joystick.

These circuits have not been tested with the PC*jr*, but they should be fully compatible with it. The PC*jr BASIC* and *Technical Reference* manuals indicate that, with the exception of the pin connections, the PC*jr*'s built-in joystick port is identical to the PC Game Control Adapter. Performance with PC compatibles is hard to predict, but if IBM's Game Control Adapter card can be used in the computer, chances are good for full compatibility in this area.

An IBM PC joystick consists of two potentiometers at right angles to each other, plus two firebuttons; for simplicity, only the potentiometers will be considered here. The computer senses the position of the joystick by measuring the resistance of each potentiometer, which varies from 0 to 100,000 ohms. This is done by timing how long it takes a capacitor of known value to charge through the unknown resistance.

Figure 1 shows a simplified version of the circuitry inside the joystick port; figure 2 shows the pin connections. One end of the resistance to be measured is connected to the positive 5-volt supply; the other end is connected, through a 2200-ohm resistor, to the capacitor. Normally, a switching transistor keeps a short circuit across the capacitor to prevent it from charging; the PC reads the joystick position by removing the short circuit and timing how long it takes the capacitor to charge to approximately 3.3 volts. The result is a number between 0 and 255, roughly equal to the resistance in kilohms.

This result can be accessed in BASIC using the functions STICK(0), STICK(1), STICK(2), and STICK(3), one for each of the four potentiometers (there are two in each of the two joysticks). When the value of STICK(0) is requested, the PC reads the positions of all four potentiometers; when STICK(1), STICK(2), or STICK(3) is requested, the results of readings that were taken simultaneously with the most recent call to STICK(0) are returned.

The program in listing 1 outputs a continuous display of the value of STICK(0) that can be used while experimenting. Only STICK(0) is used in this article, for the sake of simplicity, but remember that the PC can accommodate *four* copies of each circuit given here, all operating simultaneously.

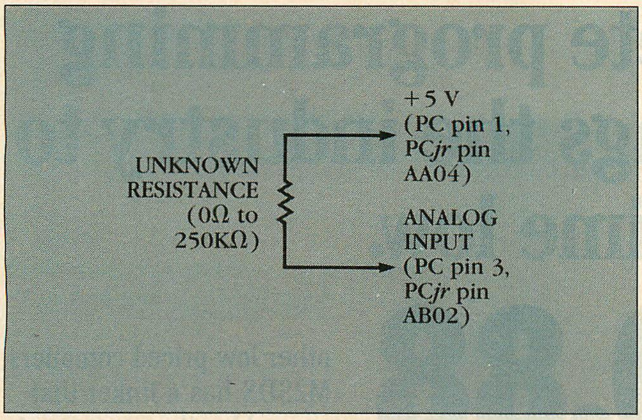
Naturally, the unknown resistance need not be a joystick potentiometer. It can be a resistor or anything else with a resistance in the appropriate range (see figure 3). To read out the actual resistance in ohms, some calibration is required, since the values of the resistors and capacitors inside the joystick port can vary from one PC to another. The program in listing 2 will perform the calibration. At the beginning of each session, readings are taken of two known resistances, one of which is 0 ohms (obtained by shorting across the terminals where the unknown resistor should go); the other should be a resistor with an accurately known value between 100 and 200 kilohms.

The PC can also measure capacitance, but the circuit required is slightly more complicated: it has two components instead of one (figure 4). The idea is to measure the time taken to charge the unknown capacitor in addition to the capacitor inside the PC. The requisite program is shown in listing 3. Again, two calibration values are required; one is 0, obtained by leaving an open circuit in place of the unknown capacitor, and one should be a capacitor with an accurately known value between about 0.2 and 0.5 microfarads. The program operates over a range of about 0.01 to 0.5 microfarads, with a resolution of about 0.01 microfarads.

To make the PC respond to light level, just substitute a cadmium sulfide photocell for the resistor in the PC ohmmeter circuit. Depending on the characteristics of the photocell, calibration may turn out to be quite complicated. There is probably no one program to suit all cases, but any mathematical formula can be implemented easily on the PC.

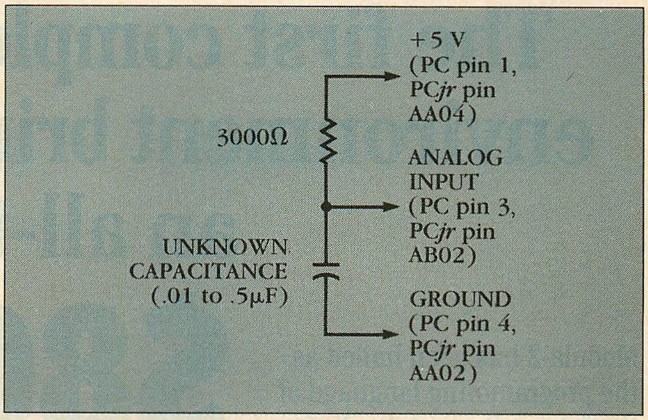
The same is true for measuring temperature, which can be done in many different ways. A thermistor—a temperature-sensitive resistor—can be used, but they are often difficult to obtain. An easier alternative is to use a silicon transistor (see figure 5). All transistors are temperature-sensitive to an ex-

FIGURE 3: *Measuring Resistance*



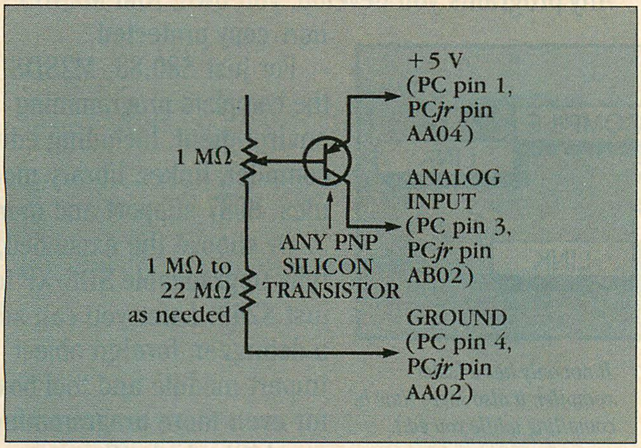
The unknown resistance need not be a joystick potentiometer; it can be anything with a resistance in the appropriate range. Because resistor and capacitor values inside the joystick port vary among PCs, some preliminary calibration is required.

FIGURE 4: *Measuring Capacitance*



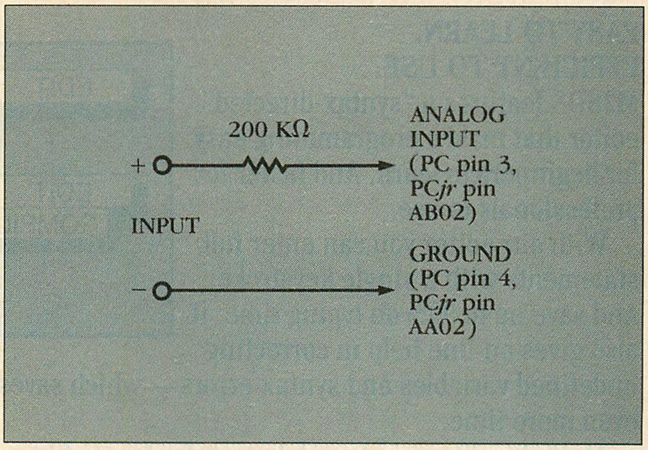
This circuit is slightly more complicated than that for measuring resistance. Capacitance is measured by assessing the time taken to charge the unknown capacitor in addition to the capacitor inside the PC. Two calibration values are needed.

FIGURE 5: *A Simple Temperature Sensor*



Any transistor can be used in this circuit, as they are all somewhat sensitive to temperature. A resolution of 1°C or better can be obtained, depending on the transistor used. A thermistor can be used, but these are often difficult to obtain.

FIGURE 6: *PC Voltmeter—Economy Model*



This circuit can be used only to measure voltages that are high enough to charge the internal capacitor to the threshold within the allowed time. The useful range is between 5 and 18 volts. It is accurate to within 0.03 volts.

tent and this sensitivity can be exploited to take measurements.

The fixed resistor shown in the diagram should be chosen by trial and error so that the value of STICK(0) comes out near 100 at room temperature. The potentiometer can then be used for fine adjustment. In most control applications, the PC will be used to detect that the temperature has reached a certain level rather than to make quantitative measurements. Note that the value of STICK(0) decreases with increasing temperature. A resolution of 1-degree Centigrade or better can be expected, depending on the type of transistor.

The most important kind of analog-to-digital conversion involves voltage, since other analog quantities can be converted into voltages relatively easily. To make the PC measure voltage, it is necessary to convert the unknown voltage into a constant or nearly constant current and use this to charge the internal capacitor; the higher the voltage, the shorter the charging time will be. The voltage will then be proportional to the reciprocal of STICK(0), rather than to STICK(0) itself, and resolution will be best at lower voltages—which is as it should be, since small voltage differences matter most when the total voltage is small. Listing 4 is a program that can be used with any of the PC voltmeter circuits given here. It requires calibration from two known voltages, both in the range of the circuit used.

The simplest way to convert a voltage to current is to run it through a resistor; this is the method used in the circuit in figure 6. But this circuit can measure only voltages that are high enough to charge the capacitor to the threshold within the time allowed, which means that the circuit's useful range is about 5 to 18 volts. Within this range, it is quite accurate. I assembled a test version and calibrated it at 5 and 12 volts using VOLT.BAS; it was accurate to within 0.03 volts for all values between.

Figure 7 is the deluxe model PC voltmeter. Its useful range covers 0 to about 6 volts; more importantly, no adjustments are necessary—the software can do all calibration because there is so little variation among units.

The circuit, a voltage-controlled current source, uses a type 324 quad operational amplifier integrated circuit (op amp IC). The output of the first stage is the same as the input voltage. Resistors R1, R2, and R3 form a summing network. A small, constant bias is

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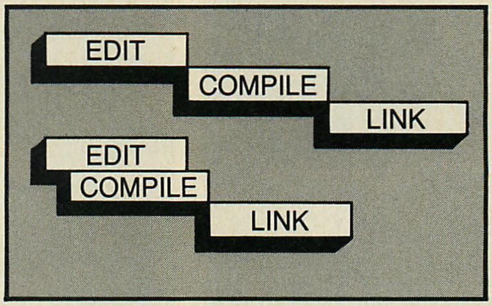

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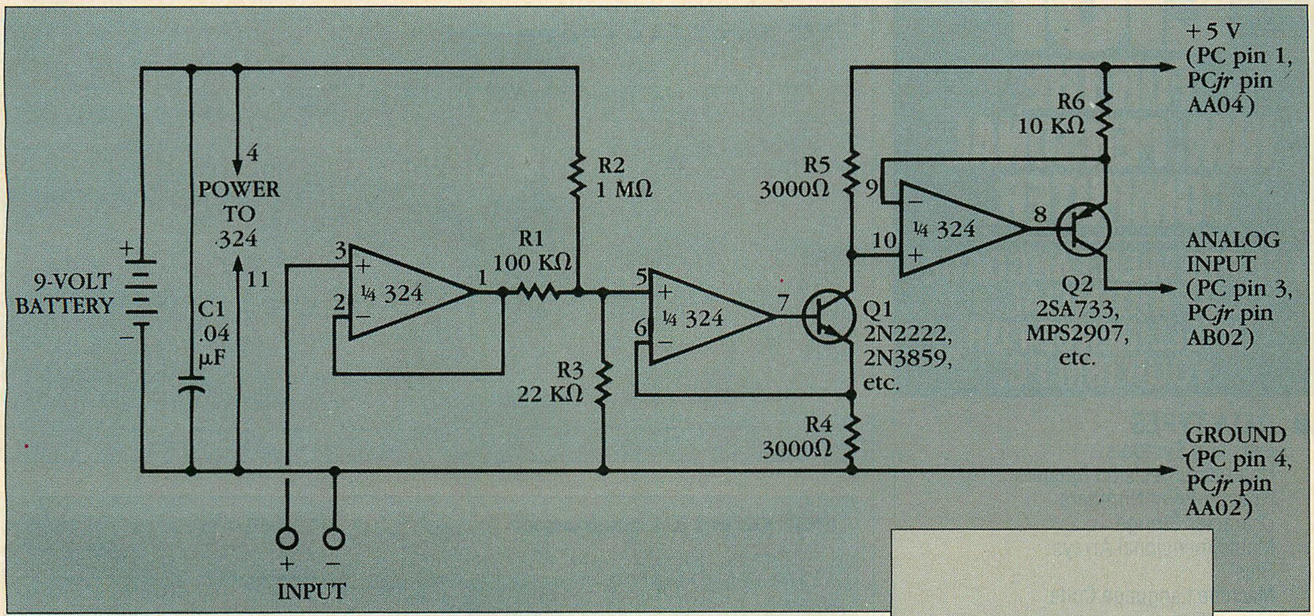
FIGURE 7: *PC Voltmeter—Deluxe Model*



This circuit requires no adjustments and all calibration can be done from software. The useful range of measurement is from 0 to about 6 volts; it is safe to about 30 volts. Note: make certain that input polarity is not reversed.

added to the input voltage so that 0 volts input will not give 0 output current (if it did, the PC's capacitor would not charge and it would be impossible to take a reading). The second and third op amps, the two transistors, and resistors R4, R5, and R6 constitute the current source itself. The voltages across R4, R5, and R6 are held equal; the output current is equal to this voltage divided by the value of R6.

The input and output voltages of the type 324 op amp can swing down all the way to 0 volts, making a negative power supply unnecessary. (For this reason, only the 324 or an exact equivalent can be used in this circuit.) However, a problem is posed by the upper limit of the 324's output voltage, which is 1.5 volts below the positive supply. If the 324 were powered from the 5-volt supply, its output could not go above 3.5 volts, and the capacitor in the PC would not charge within the time allowed. The solution is to power the 324 (and obtain R2's bias voltage) from a higher-voltage power supply. In figure 7, this is shown as a 9-volt battery, but any source of between 7.5 and 30 volts DC will do; the current required is less than 1 mA. If this circuit is built on the prototyping area of the PC Game Control Adapter Card, the PC's positive 12-volt supply can be tapped.

Figure 8 shows a more subtle solution that enables the whole circuit to run off the 5-volt power available at the joystick port pins. An ICL 7660 voltage converter IC, operating as an oscillator at about 8 kHz, feeds a voltage doubler to give about 9 volts out from 5 volts in. The output voltage is slightly higher if a type 1N34 or equivalent germanium diodes are used, although silicon signal diodes (1N914, 1N4148) are suitable.

The component values in the deluxe PC voltmeter are not highly critical, but it is good to use 5-percent resistors of the values specified. R4 and R5 should be well matched. R6 controls the range of readings obtained; adjust it to get STICK(0) to equal about 200 or 220 for 0 volts input, and below 50 for the highest voltage to be measured. The transistors can be any small-signal silicon type (one NPN, one PNP), preferably with gain (beta) above 50. The circuit is designed to virtually cancel out variations in transistor gain.

Used with VOLT.BAS, the deluxe model PC voltmeter performs impressively. Using a breadboarded version of this circuit, I obtained 0.01-volt resolution for readings under 1 volt, 0.03-volt resolution up to 2 volts, and 0.1-volt resolution up to 4 volts. After calibration at 0 and 5.2 volts, the deluxe PC voltmeter agreed with my Micronta digital multimeter to within 0.02 volts, resolution permitting, over the entire 0-to-5-volt range—I am now not certain which of the two is the more accurate!

One precaution: the input of the 324 sources a small current that can be

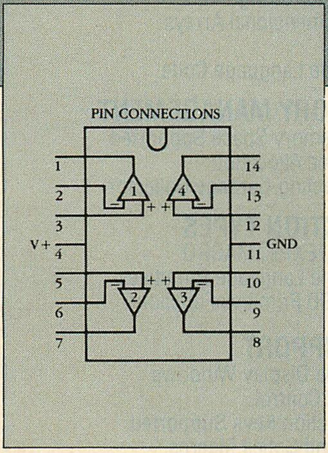
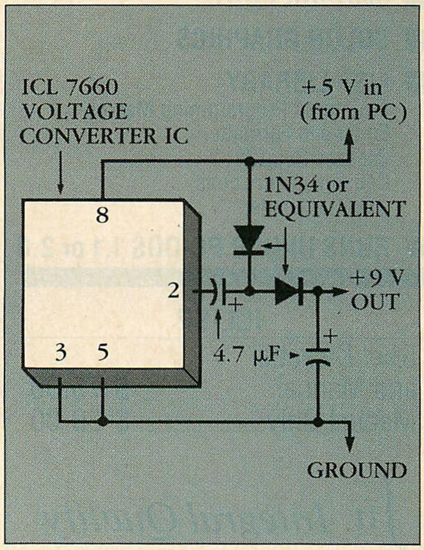
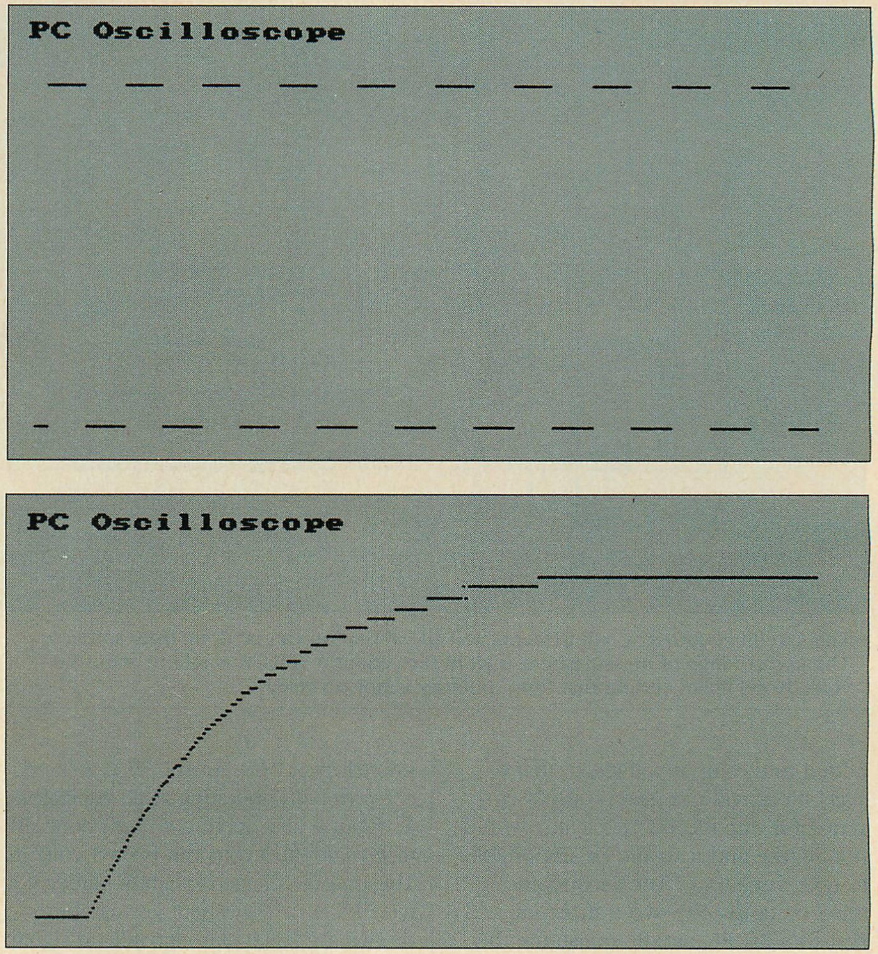


FIGURE 8: *Substitute for 9-volt Battery in Figure 7*



This circuit allows the voltmeter to be run from the 5-volt power available at the joystick pins. The ICL 7660, operating as an oscillator at about 8kHz, feeds a voltage doubler and outputs about 9 volts from the input.

FIGURE 9: *PC Oscilloscope Output*



These figures display the output from OSCILL.BAS (listing 5) taken with the deluxe model PC voltmeter circuit, illustrated in figure 7. The top figure shows a 1-Hz square wave; the lower figure shows the charging curve of a capacitor.

as high as 500 nanoamperes, though 20 nanoamperes is more typical. This can distort readings of extremely high impedance voltage sources, such as the charge on a capacitor. A 1-megaohm resistor across the input greatly reduces this effect and makes possible readings through a standard oscilloscope probe in either the 1:1 or 1:10 configuration. Alternatively, the input voltage range can be extended with a voltage divider.

OSCILL.BAS (listing 5) plots a graph of voltage against time, functioning like a chart recorder or slow, single-sweep oscilloscope. The front end is exactly like the PC voltmeter and can be used with any of the same circuits, but the results are displayed as a graph of voltage against time. A sweep takes about nine seconds and could be slowed down by inserting delay loops. (The PC takes the same time to evaluate STICK(0) whether the capacitor charges slowly or quickly; if this were not so, the joystick would be more responsive at one end of its range).

The drawings in figure 9 show the PC oscilloscope's interpretations of, respectively, a 1-Hz square wave and the charging curve of a capacitor, taken with the deluxe model PC voltmeter circuit. The bottom figure shows how the resolution is highest at low voltages.

This PC oscilloscope program is only the beginning. With proper programming, the PC can do far more than any ordinary oscilloscope. It could generate logarithmic scales on one or both axes, mathematically transform the data before displaying it, automatically cut out long, monotonous stretches from the waveform, store the readings, or even plot calculated values against measured ones on the screen. The PC costs little more than a good chart recorder and is a lot more versatile. It can be the most powerful piece of equipment in the laboratory.

Michael A. Covington conducts research in artificial intelligence and supercomputer applications at the University of Georgia.

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Max. Characters Per Card	**969**	NO Files	480
Search	**YES**	NO Files	**YES**
Auto Alphabetize	**YES**	NO Files	**YES**
Print Card	**YES**	NO Files	**YES**
Print Deck	**YES**	NO Files	**YES**
CALENDAR			
Daily Notes	**YES**	NO	NO
Mark Important Days	**YES**	NO	NO
Date Range	**1752-2099**	1901-2099	1901-2099
APPOINTMENT BOOKS			
Multiple Appt. Books	**YES** (1-10)	NO	NO
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Print Appointment Book	**YES**	**YES**	**YES**
ALARM CLOCK			
Display Time	**YES**	NO Alarms	**YES**
Hourly Chimes	**YES**/Optional	NO Alarms	NO
Time Format	**AM / PM**	NO Alarms	AM / PM
Display Alarm Message	**YES**	NO Alarms	NO
Number of Alarms	**9**	NO Alarms	Many
CALCULATOR			
On-Screen Tape	**YES**/Optional	NO	NO
Printing Tape	**YES**/Optional	NO	NO
Percentage Function	**YES**	NO	**YES**
Display With Commas	**YES**/Optional	NO	NO
Floating/Fixed Decimals	**YES/Both**	Fixed	Floating
Memory	**YES**	**YES**	**YES**
Insert Result in Work	**YES**	**YES**	**YES**
Max. Display Digits	**15**	18	12
Display Number > Above	**YES/Exponential**	NO	NO
Scientific Notation	**YES**	NO	NO
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File Size Limit	**64K**	50K	4.4K
Variable Window Size	**YES**	**YES**	NO
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Print Window Only	**YES**	**YES**	**YES**
Undelete Key(s)	**YES**	**YES**	NO
Cut & Paste Screen Text	NO (Note 1)	Import Only	NO
KEYBOARD ENHANCER			
Number Keys Redefined	**YES Up to 60**	NO/Not Avail.	NO/Not Avail.
Total Keystrokes	**YES** 2500	NO/Not Avail.	NO/Not Avail.
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100% Memory Resident	**YES**	NO	NO
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Can Remove Functions	**YES**	NO	NO
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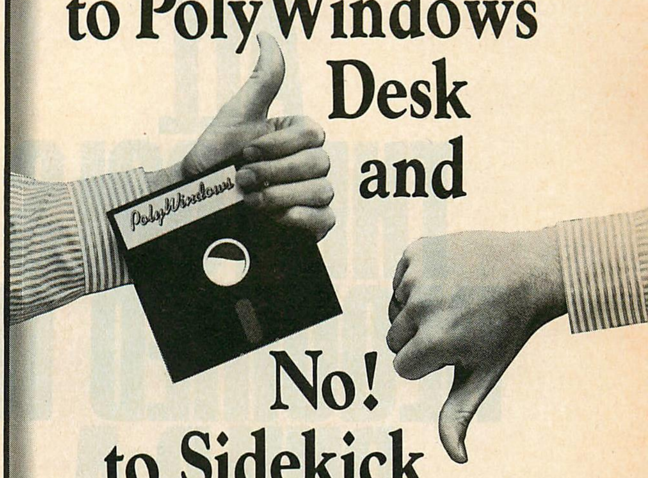

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LISTING 1: ANALOG.BAS

```
10 ' Program to show analog reading from joystick port
30 CLS
40 LOCATE 1,1
50 Q=STICK(0)
60 PRINT Q
70 GOTO 40
```

LISTING 2: OHM.BAS

```
10 ' PC OHMMETER -- Copyright 1984 Michael A. Covington
20 ' Uses PC Game Control Adapter to measure resistances up to
30 ' 200 kilohms with a resolution of approximately 1 kilohm.
40 ' Unknown resistance is connected across pins 1 and 3 of
50 ' PC joystick socket.
70 CLS : KEY OFF
80 PRINT "PC OHMMETER"
90 PRINT
100 PRINT "Connect probes together, then press any key..."
110 IF INKEY$="" THEN 110
120 OFFSET = STICK(0)
130 IF (OFFSET < 1) OR (OFFSET > 10) THEN BEEP : GOTO 90
140 PRINT "Zero set"
150 PRINT
160 PRINT "Connect calibration resistor, then press any key..."
170 IF INKEY$="" THEN 170
180 READING = STICK(0)
190 IF READING > 50 THEN 230
200 BEEP : PRINT
210 PRINT "Use a calibration resistor ";
215 PRINT "between 100 and 200 kilohms."
220 GOTO 150
230 PRINT "Value of calibration resistor ";
235 INPUT "(in kilohms)? ",RESISTANCE
240 FACTOR = (READING - OFFSET) / RESISTANCE
250 PRINT
260 PRINT "Calibrated"
280 PRINT:PRINT
290 PRINT "PC OHMMETER at your service..."
300 PRINT "Press any key to take a reading"
310 PRINT
320 IF INKEY$="" THEN 320
330 READING = STICK(0)
340 RESISTANCE = (READING - OFFSET) / FACTOR
350 COLOR 15,0
360 PRINT INT(RESISTANCE+.5); " kilohms"
370 COLOR 7,0
380 GOTO 280
```

LISTING 3: CAPAC.BAS

```
10 ' PC Capacitance Meter -- Copyright 1984 Michael A. Covington
20 ' Uses PC Game Control Adapter to measure capacitances
30 ' up to 0.5 microfarad with a resolution of about .01 microfarad.
40 ' Connect a 3000-ohm resistor across pins 1 and 3 of PC joystick
50 ' socket; unknown capacitance, across pins 3 and 4.
70 CLS : KEY OFF
80 PRINT "PC CAPACITANCE METER"
90 PRINT
100 PRINT "Make sure no capacitor is presently connected,"
110 PRINT "then press any key..."
120 IF INKEY$="" THEN 120
130 OFFSET = STICK(0)
140 IF (OFFSET < 1) OR (OFFSET > 20) THEN BEEP : GOTO 90
150 PRINT "Zero set"
160 PRINT
170 PRINT "Connect calibration capacitor, then press any key..."
180 IF INKEY$="" THEN 180
190 READING = STICK(0)
200 IF READING > 20 THEN 240
210 BEEP : PRINT
220 PRINT "Use a calibration capacitor between 0.2 and 0.5 microfarad."
230 GOTO 160
240 INPUT "Value of calibration capacitor (in microfarads) ? ",CAPACITANCE
250 FACTOR = (READING - OFFSET) / CAPACITANCE
270 PRINT:PRINT "Calibrated"
290 PRINT:PRINT
300 PRINT "PC CAPACITANCE METER at your service..."
310 PRINT "Press any key to take a reading"
320 PRINT
330 IF INKEY$="" THEN 330
340 READING = STICK(0)
350 CAPACITANCE = (READING - OFFSET) / FACTOR
360 COLOR 15,0
370 PRINT USING "##.## microfarad"; CAPACITANCE
380 COLOR 7,0
390 GOTO 290
```

LISTING 4: VOLT.BAS

```
10 ' PC VOLTMETER -- Copyright 1984 Michael A. Covington
20 ' Uses the PC Game Control Adapter to measure voltage.
30 ' Can be used with any of the voltmeter circuits in
40 ' the accompanying article provided the calibration
50 ' voltages used are within the range of the circuit.
70 CLS : KEY OFF
80 PRINT "PC VOLTMETER"
90 PRINT
100 PRINT "Connect first calibration voltage, ";
105 PRINT "then press any key."
110 IF INKEY$="" THEN 110
120 READING1 = 1/STICK(0)
140 PRINT "Reading taken."
141 PRINT
142 INPUT "Value of that voltage (in volts)";VOLTAGE1
150 PRINT
160 PRINT "Connect second calibration voltage, ";
165 PRINT "then press any key."
170 IF INKEY$="" THEN 170
180 READING2 = 1/STICK(0)
185 PRINT "Reading taken."
186 PRINT
190 INPUT "Value of that voltage (in volts)";VOLTAGE2
200 FACTOR = (READING2-READING1)/(VOLTAGE2-VOLTAGE1)
210 OFFSET = READING2 - (VOLTAGE2*FACTOR)
260 PRINT:PRINT "Calibrated"
280 PRINT
290 PRINT "PC VOLTMETER at your service..."
300 PRINT:PRINT "Press any key to take a reading"
320 IF INKEY$="" THEN 320
330 READING = 1/STICK(0)
340 VOLTAGE = (READING-OFFSET)/FACTOR
350 COLOR 15,0
360 PRINT USING "##.### volts";VOLTAGE
370 COLOR 7,0
380 GOTO 280
```

LISTING 5: OSCILL.BAS

```
10 ' PC OSCILLOSCOPE -- Copyright 1984 Michael A. Covington
20 ' A graphics adaptation of PC Voltmeter.
30 ' Requires the same input and calibration procedure.
50 CLS : KEY OFF
60 PRINT:PRINT "PC OSCILLOSCOPE"
80 PRINT "Connect first calibration voltage, ";
85 PRINT "then press any key."
90 IF INKEY$="" THEN 90
100 READING1 = 1/STICK(0)
110 PRINT:PRINT "Reading taken."
130 INPUT "Value of that voltage (in volts)";VOLTAGE1
140 PRINT
150 PRINT "Connect second calibration voltage, ";
155 PRINT "then press any key."
160 IF INKEY$="" THEN 160
170 READING2 = 1/STICK(0)
180 PRINT:PRINT "Reading taken."
200 INPUT "Value of that voltage (in volts)";VOLTAGE2
210 FACTOR = (READING2-READING1)/(VOLTAGE2-VOLTAGE1)
220 OFFSET = READING2 - (VOLTAGE2*FACTOR)
230 PRINT "Calibrated"
240 PRINT:PRINT
260 PRINT "Press any key to start."
270 PRINT "A beep will signal that the trace is"
280 PRINT "complete; you may then press any key"
290 PRINT "to start another one."
300 IF INKEY$="" THEN 300
310 SCREEN 1,0 : CLS
320 LINE (0,0)-(320,0)
330 LINE -(320,200)
340 LINE -(0,200)
350 LINE -(0,0)
360 LOCATE 2,2:PRINT "PC Oscilloscope"
370 X=10
380 WHILE X<301
390    VOLTAGE = ((1/STICK(0))-OFFSET)/FACTOR
400    IF VOLTAGE>5 THEN VOLTAGE=5
410    IF VOLTAGE<0 THEN VOLTAGE=0
420    Y = 185 - 30*VOLTAGE
430    PSET(X,Y)
440    X=X+1
450 WEND
460 BEEP
470 IF INKEY$="" THEN 470 ELSE 310
```

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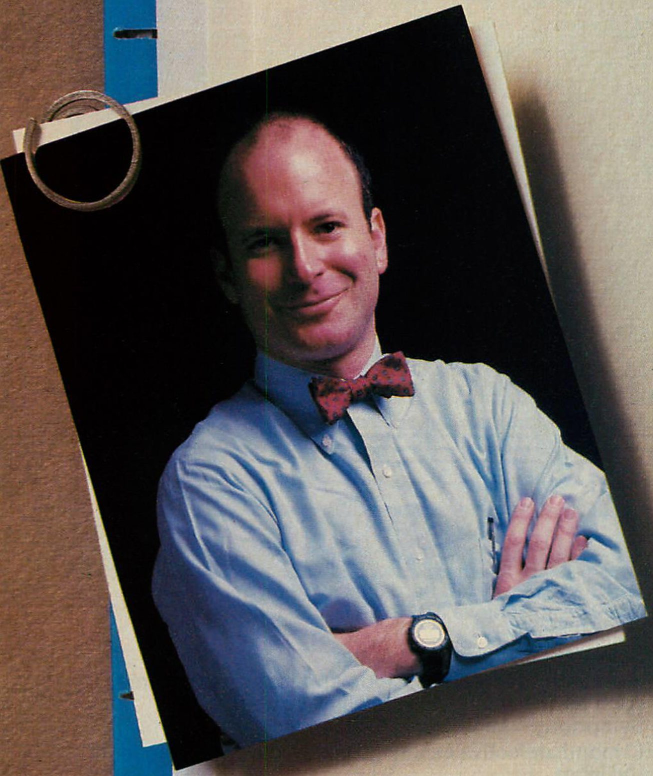

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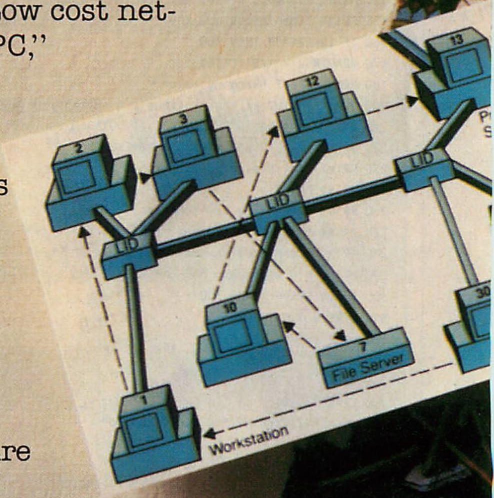

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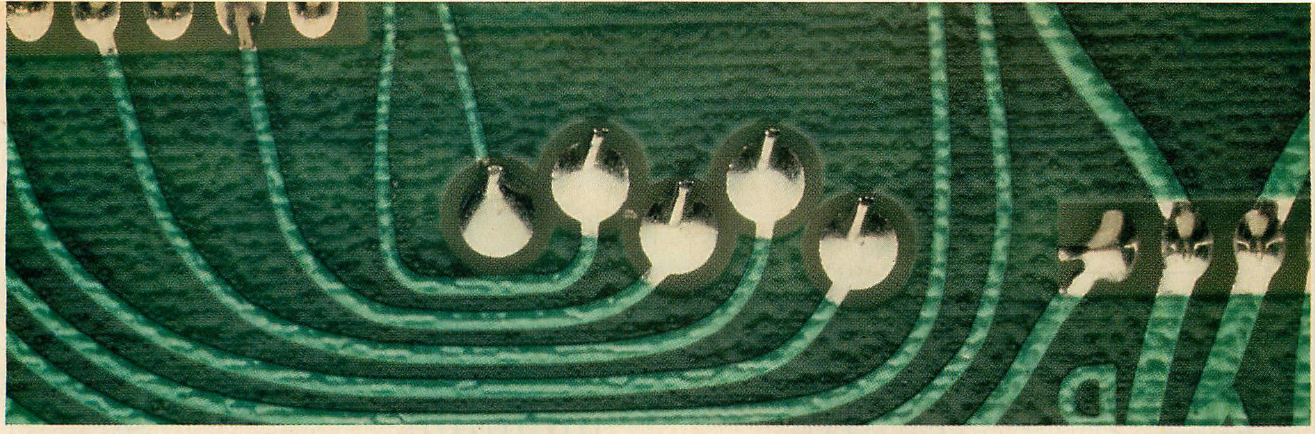

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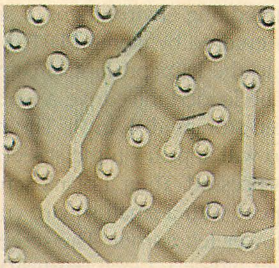


WILLIAM H. MURRAY

Computer-aided design (CAD) tools allow digital circuits to be created and simulated without a human hand ever touching a prototype board, soldering iron, or actual components. Once the design is finished, the bugs worked out of the circuit, and the working model completed, the prototype must be made ready for production. The production process requires a printed circuit board that will hold the actual circuit components.

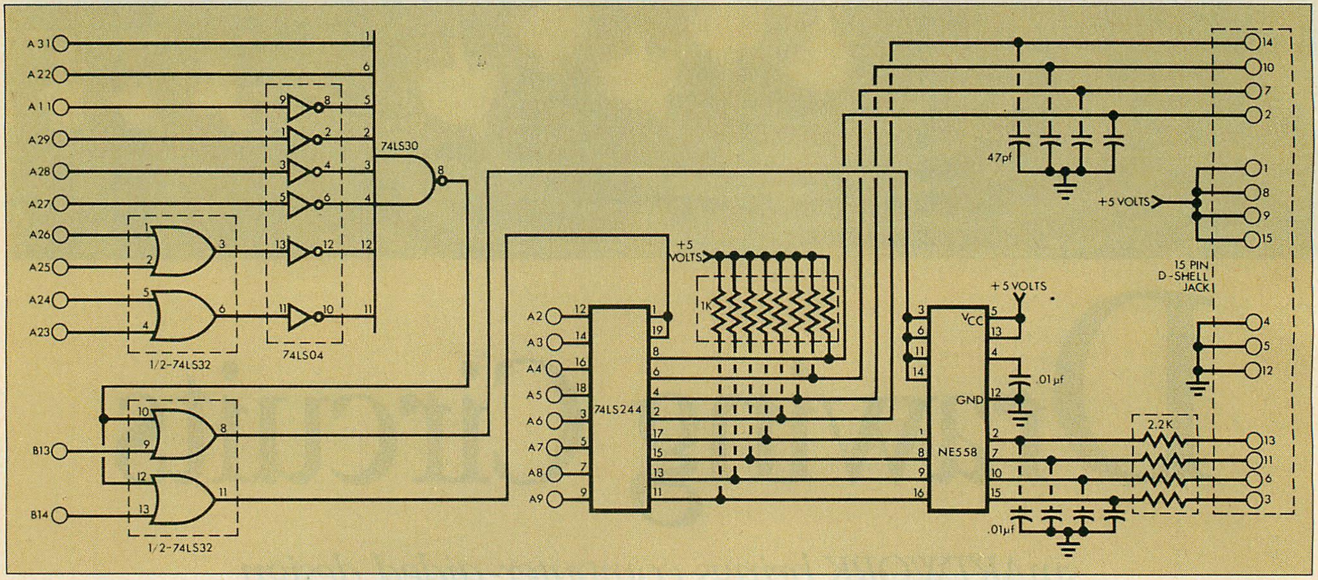
SMARTWORK from the Wintek Corporation is software that is designed to aid in the production of the artwork used for printed circuit boards. It is made to work on a PC/XT with 192KB of RAM, two 360KB disks, a color graphics adapter, and an IBM or Epson printer. A Houston Instruments DMP-41 or DMP-40 pen-and-ink plotter, a Hewlett-Packard 7475A plotter, and a Microsoft Mouse are optional equipment.

Prior to the introduction of computer-aided design techniques, printed circuit board design was a tedious manual task. In his book *Photoresist*, William S. DeForest credits W. H. Talbot, in 1852, with the first patent for a photoetching process that could be used on copper. In 1925 C. Ducas patented a technique that placed a layer of copper on a nonconductive base by stenciling. In 1944 Eisler patented a printed circuit board technique similar to the techniques used today, but it did not catch on until the transistor age of the early and mid-1960s.

A popular method of circuit board design still used today involves a technique for creating a pattern on a piece of plastic (drafting film) that represents an enlarged circuit board. Copper pathways are laid out with black tape of various widths. Pads where components would pass through a board or connect to other components are shown using another set of sticky black tape patterns. On these one-sided boards, copper pathways can never cross one another, so component placement is very impor-

PHOTOGRAPHS • JOHN LEI

FIGURE 1: *Address Decoder*



Assuming the pin assignments shown above, smARTWORK will develop the connection paths on this game adapter circuit for the XT. The NE55B timer chip and the 74LS244 line driver-receiver chip are used.

tant to minimize wire jumpers on the finished board. Once the printed circuit board design is acceptable, the plastic-tape pattern is photographically reduced and becomes the mask for the photo-etching process.

This method of circuit board design has several disadvantages: once the circuit design is completed, it is difficult to modify (the tape is not reusable, and electrical pathways are more or less set); minor changes often require a completely new circuit board design to be drafted; and the cost of a draftsperson for initial layout and future modifications can be high.

GAME BOARD DESIGN

Computer-aided design can overcome these disadvantages. A step-by-step examination of the design process for a game-adapter board for the XT will demonstrate how a printed circuit board can be created on a computer using SMARTWORK. The example assumes that the pin connections are already established (see figure 1).

Game-adapter circuits for the XT, whether offered through IBM, AST, Quadram, or others, are more-or-less standard circuits that consist of an address decoder, a timer, and a line driver/receiver. Although address decoding circuits vary from manufacturer to manufacturer, several companies, including IBM, have settled on the NE558 timer chip and the 74LS244 line driver/receiver chip as standards.

The command structure of SMARTWORK is divided into three major categories, as shown in table 1: command line inputs, display control functions, and single keystroke functions.

The editing environment of SMARTWORK is entered by typing EDIT in response to the DOS prompt. SMARTWORK should be loaded into drive A: and a formatted storage disk in B:. The product logo will appear on the screen until a key is pressed. Then a blank screen will appear with a small square cursor in the lower left corner. The screen can represent either a 2-inch (vertical) by 4-inch (horizontal) finished board or a portion of a board; the size of the total board can be as large as 10 inches by 16 inches. The user can move into different 2-by-4-inch portions of the larger board by using either the arrow keys or a mouse to move the cursor vertically or horizontally (to the right) of the cursor's starting position.

The game-board adapter being used as an example for this article was designed on an untrimmed 4-by-4-inch board (actual size is 4.2 by 3.9).

If the Return key is pressed once, the command line will request an input. If a mouse is being used, this is the point at which the mouse driver should be installed by typing the word MOUSE, followed by a return.

Printed circuit boards can be designed double-sided with SMARTWORK. To view the top of a board, press PgUp, and to view the bottom, press PgDn.

Designs created with SMARTWORK will have the following specifications:

- Regular lines will be 12 mils wide (0.012 inches)
- Wide lines will be 50 mils
- Pads will be 62 mils in diameter
- The minimum spacing between conductors will be 19 mils.
- Each movement of the screen cursor represents a finished board distance of 50 mils.

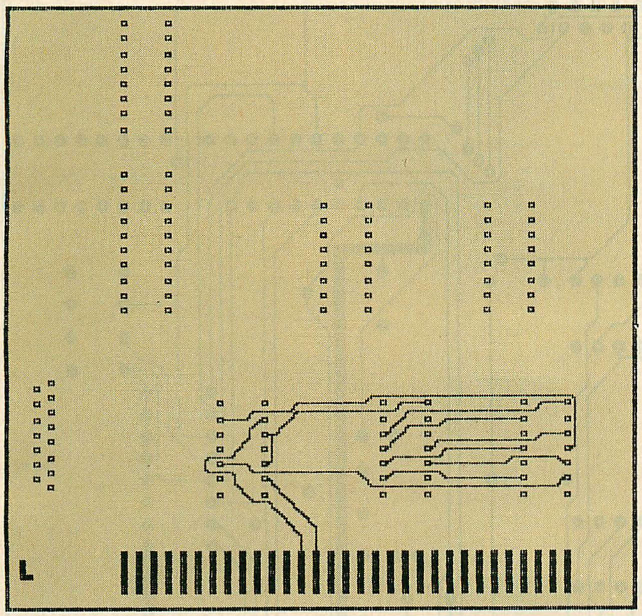
In the game-board adapter example, the edge-strip connectors were placed on the upper and lower surfaces of the board by moving the cursor to the correct positions and placing several fat cells (via the F7 key) in a row. There are 31 edge connectors on each side of the board. The pads for the five ICs and two resistor networks were put on the board with the DIP command. For example, a 140-pin DIP pattern can be placed by typing DIP N 14 3. *N* refers to north of the cursor position, *14* to the total number of pads, and *3* to the number of 0.1-inch intervals between the two rows.

When all the DIP pads are completed, the SIP command is used to place the pads for the joystick jack to the left of the circuit board. For example, SIP N 8 will place eight pads, vertically upward from the current cursor position. Putting an *L* in the lower lefthand corner of the lower board and a *U* in the lower lefthand corner of the upper board will help the user remember which side of the board he is working on after starting to trace the connections from pin to pin.

Figure 2 (lower board) and figure 3 (upper board) show the tracing for the address decoder of the game adapter. Because SMARTWORK allows the

FIGURE 2: *Partially Designed Lower Board*

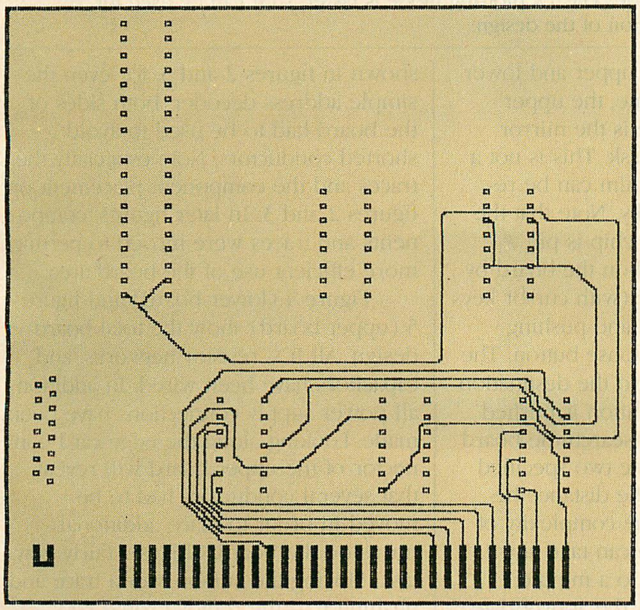
```
checkplot v1.0 r4     4 Jan 1985   17:09:40
file:   b:board2                lower layer
approx. size:                   holes:  125
4.10 by 3.90 in.
```



This plot of the lower portion of the game adapter shows the placement of the major components on a 4-by-4-inch board. Some of the wiring for the address decoder is in place.

FIGURE 3: *Partially Designed Upper Board*

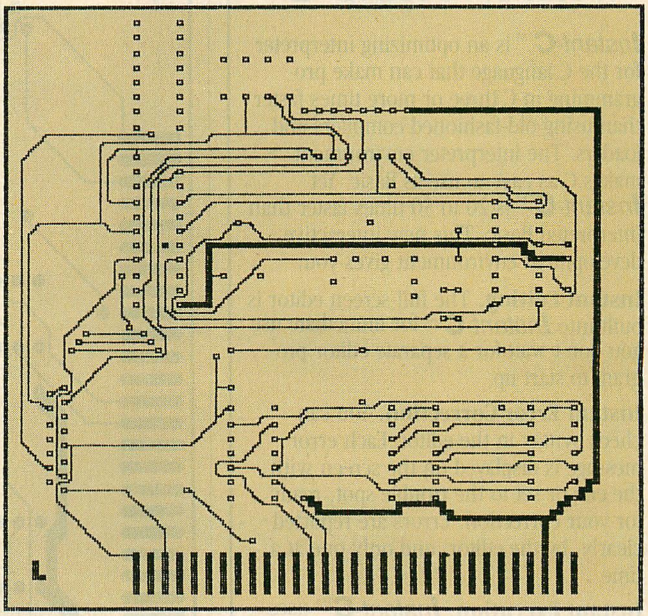
```
checkplot v1.0 r4     4 Jan 1985   17:06:29
file:   b:board2                upper layer
approx. size:                   holes:  125
4.10 by 3.90 in.
```



The upper portion of the game adapter as plotted by smARTWORK is a mirror image of the lower board since both the upper and lower portions can be viewed at the same time. The U identifies the side to the author.

FIGURE 4: *Completed Lower Board*

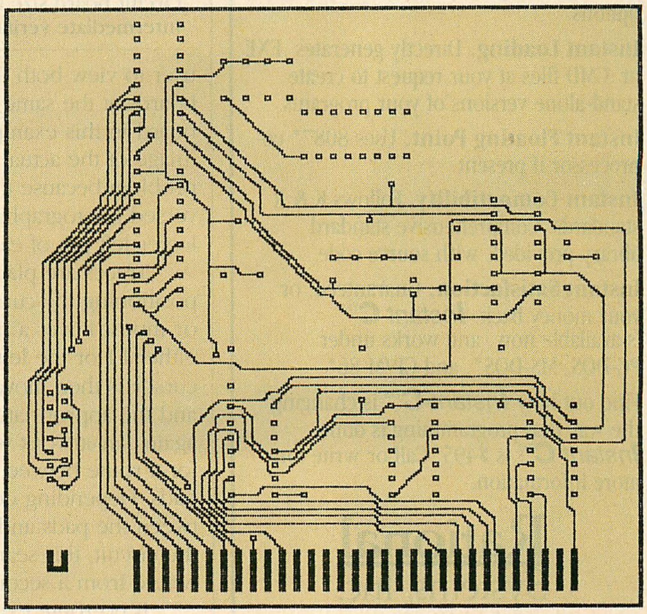
```
checkplot v1.0 r4     4 Jan 1985   17:12:13
file:   b:board4                lower layer
approx. size:                   holes:  175
4.20 by 3.90 in.
```



The completed design for the lower portion of the game adapter board. All ICs, resistor networks, and capacitors have been wired, and all power supply connections made.

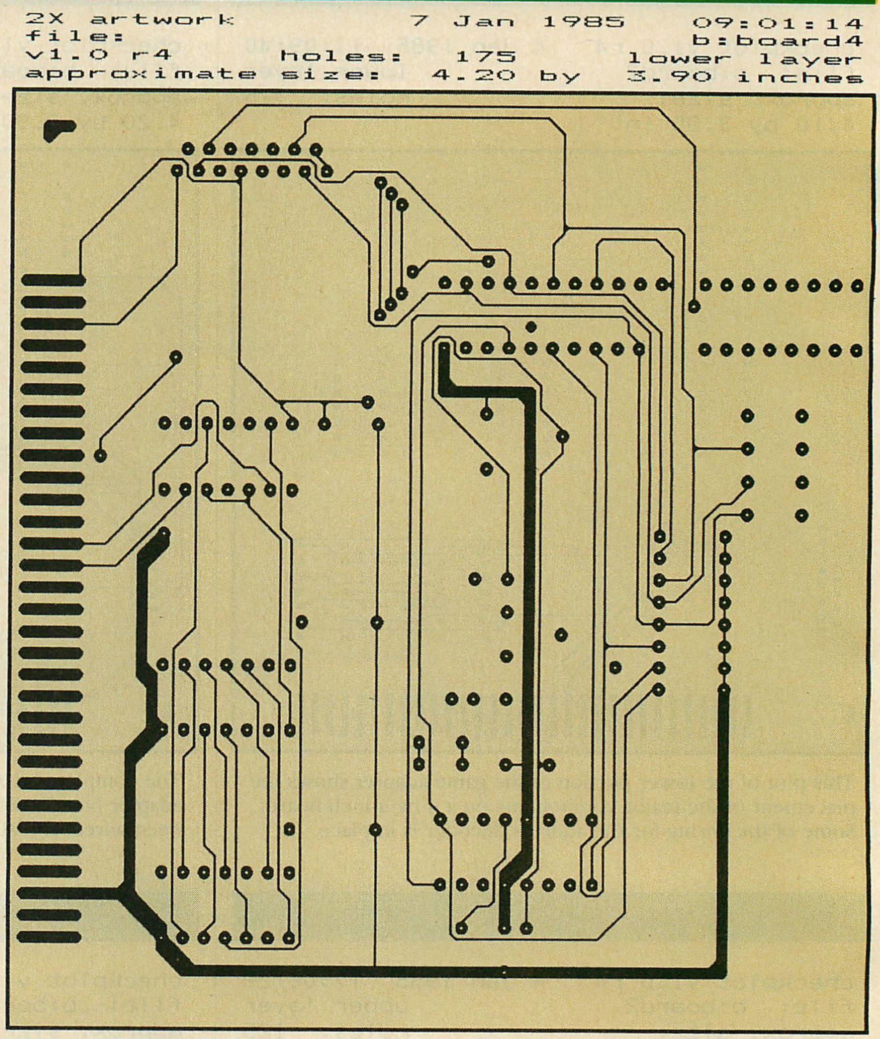
FIGURE 5: *Completed Upper Board*

```
checkplot v1.0 r4     4 Jan 1985   17:12:13
file:   b:board4                upper layer
approx. size:                   holes:  175
4.20 by 3.90 in.
```



The completed design is shown for the upper portion of the game adapter board. Several conductors had to be moved from the partial design at left by using the Remove Route function and a new path created using Mark Route.

FIGURE 6: *2X Plot of Lower Board*



Finished artwork is plotted in 2X mode, shown reduced approximately to actual circuit board size mode. The 1X plotting mode is faster, so it can be used for intermediate verification of the design.

user to view both the upper and lower boards at the same time, the upper board in this example is the mirror image of the actual mask. This is not a problem because the film can be reversed photographically. Note that the lower left pin of each chip is pin #1.

Traces are placed on the board by positioning the cursor (with cursor keys or mouse) over a pad and pushing either F1 or the left mouse button. The cursor is then moved to the destination and the appropriate button is pushed again. SMARTWORK will search the board for a route between the two specified pads. Depending on the distance between the pads and the complexity of the circuit, this search can take anywhere from a second to a minute.

If no route exists, the appropriate screen message will appear. The only choice then is to flip the board and hope that the route can be completed on the other side of the board. As shown in figures 2 and 3, for even the simple address decoder, both sides of the board had to be used to avoid shorted conductors. Note especially the traces and the component placement on figures 2 and 3. In later figures, components and traces were moved to permit more efficient use of the board area.

Figure 4 (lower board) and figure 5 (upper board) show the total board design. All ICs, resistor networks, and capacitors have been wired. In addition, all power supply connections have been made. Looking along the edge card connector of the upper board will reveal that several conductors had to be moved in order to place additional traces on the board. This is a fairly easy task. Moving the cursor over a trace and pushing F2—the remove route key—or the right mouse button will cause the trace to be removed.

A new trace can be forced into the desired position with this technique:

TABLE 1: *smARTWORK Commands*

COMMAND LINE INPUT

CLEAR	Clears the current screen of all art
CLEAVE <direction>	Widens space between traces for additional insertions
DIP <direction><pins> <spacing>	Automatically places pads in the correct positions for DIP chips
LOAD <file name>	Retrieves previous art
MOUSE	Loads the mouse driver
QUIT	Returns to DOS
SAVE <filename>	Saves the current art
SIP <direction> <pins>	Automatically places in-line pads
(Backspace key)	Deletes a character
(Esc)	Erases a response
(Enter)	Processes a response

DISPLAY CONTROL FUNCTIONS

Alt-F1	Toggles between color/no color mode
Alt-F2	Toggles color intensity
Alt-F3	Toggles color scheme
Alt-F4	Toggles background color
Alt-F5	Toggles opaque/transparent mode
Alt-F6	Toggles active layer's color
Alt-F7	Toggles window size

SINGLE KEYSTROKE FUNCTIONS

F1 — Mark route	Marks the beginning of a circuit trace or route. It must start at a pad on the board
F2 — Remove route	Removes a route or trace between pads
F3 — Place pad	Places a pad on the board. A pad is three-dimensional in that it passes through the board to both sides.
F4 — Remove a pad	Removes a pad and any traces connected to it
F5 — Widen	Increases the width of the trace (conductor) where possible
F6 — Shrink	Reduces the size of a trace that was previously widened
F7 — Place fat cell	Places a square of copper on the board for making connections. Repeated use of fat cells can produce a pattern of almost any desired shape.
F8 — Repeat route	Repeats a routing pattern

smARTWORK accepts three types of commands: command line input; Alt-function keys; and function keys.

place the cursor on a pad and press F1 (the mark route key); move the cursor a short distance and push F1 again to draw a conductor (trace) from the pad to the current cursor position; move the cursor again (a short distance) and press the key; repeat this procedure until the route is completed as desired. The design process is likely to require quite a bit of trace moving.

SMARTWORK offers some useful screen options with an RGB monitor. By pressing Alt-F1, the user is able to switch between viewing a single layer (one-color display) and a dual layer (multicolor display). If a black-and-white monitor is used with the color graphics adapter, the following monitor commands will not provide very good viewing results.

Alt-F2 allows the user to toggle the intensity of the background color. Alt-F3 allows two palettes of colors to appear on the screen: red, green, and yellow; or magenta, cyan, and white. Alt-F4 switches the background from black to blue. Alt-F5 displays two or three colors at one time. If the user is viewing two layers, the active layer (the one being worked on) will appear in one color, and the other layer will be in a different color. Normally, if a trace on the active layer covers a trace on the inactive layer, only the active layer's trace will be visible. With the three-color option, the overlap will be shown in the third color. Alt-F6 swaps the active-layer color with the inactive layer color, allowing four different color combinations to appear on the screen simultaneously.

Finally, Alt-F7 permits the entire 10-by-16-inch design screen to be viewed at once. Everything on the board appears squashed together on the screen and is difficult to understand. However, this large-view screen may be useful if additional components have to be placed on the board.

Printing circuit board artwork is achieved by first saving the circuit board design and then QUITing the Editor. From the DOS command level, PLOT is used to enter SMARTWORK's printing program. Currently, dot-matrix art can be achieved only on IBM and Epson printers (or compatibles). Higher quality plots can be obtained with Houston Instruments DMP-41 or DMP-40 plotters. The latest revision also supports Hewlett-Packard's 7475A plotter.

In figures 2 through 5, the 1X check plot option was used to obtain fast verification of the game-adapter design. The artwork produced with this option is fast, but not polished. The pads are somewhat square, diagonals have jagged lines, and the fat cells and wide runs have squared edges. All of this was fixed when the final artwork was produced using the 2X mode (figure 6). The 2X plots take 15 to 20 minutes (per side) to complete.

If a plot is made on either an Epson RX-80 or FX-80 printer in the 2X mode, the largest circuit board that can be printed is approximately 4 inches by 4 inches. The board is printed sideways, with the vertical dimension plotted across the screen, and the horizontal dimension plotted up and down on the sheet. Obviously, for serious production work a plotter must be considered. The border around each board surface can be removed when plotting by typing PLOT -NB after the DOS prompt.

COMPLETE MANUAL

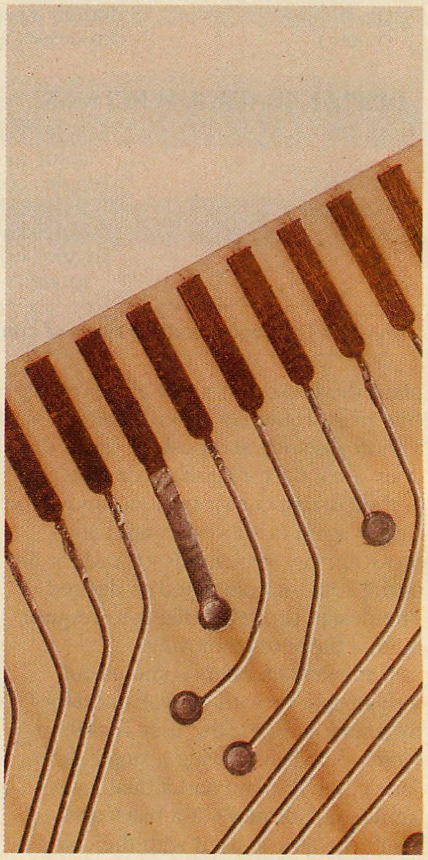
SMARTWORK arrives with a single write-protected, copy-protected diskette containing the program, a 128-page manual that completely describes the program operation, and a legal-size license agreement that limits the use of the product to one machine. Wintek will supply one back-up copy of the program if the agreement is returned.

One of SMARTWORK's strengths is its manual. It is divided into 19 well-written, easy-to-follow chapters and is extremely detailed (although not wordy) in the operation of the product. Five chapters are devoted to the use of the simple command editor, loading and saving circuit files; use of the display options; control of the screen cursor; placement of circuit pads, traces, and fat cells on the circuit board; and plotting the final design on a printer or plotter.

The remaining chapters simply go into more detail about the commands already presented and explain some ad-

vanced techniques and concepts of circuit board design. One chapter describes how to use SMARTWORK with the Microsoft Mouse. A mouse will greatly speed up output in extensive circuit board designing. The Mouse Systems Mouse can also be used.

SMARTWORK is a very interesting product with which to work. Wintek seems to have paid a lot of attention to detail, because the program works with ease. Commands can be mastered in one or two hours, and circuit board design can begin almost immediately. Four chapters in the manual are tutorial



in nature and will help even the most reluctant user become an eager supporter. For those designers who would like to tie into a small CAD circuit board design system on the XT, SMARTWORK is ideal. Applications range from industrial board design to teaching CAD applications on a small system.

SMARTWORK: $895
Wintek Corporation
1801 South Street
Lafayette, IN 47904-2993
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CIRCLE 454 ON READER SERVICE CARD

William H. Murray teaches computer science at Broome Community College in Binghamton, New York. He is a contributing editor to this magazine.

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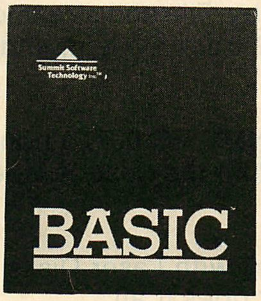

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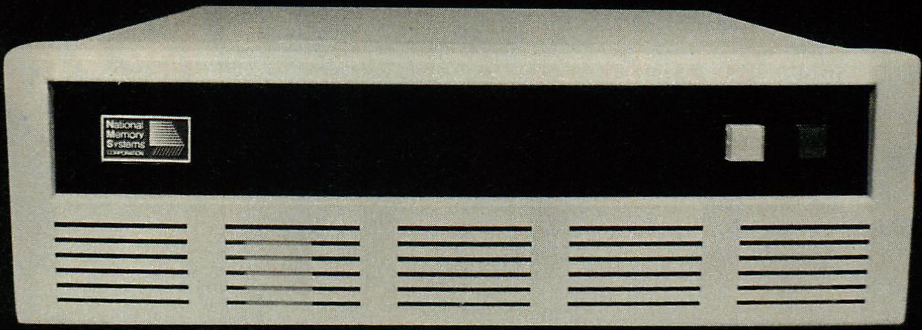

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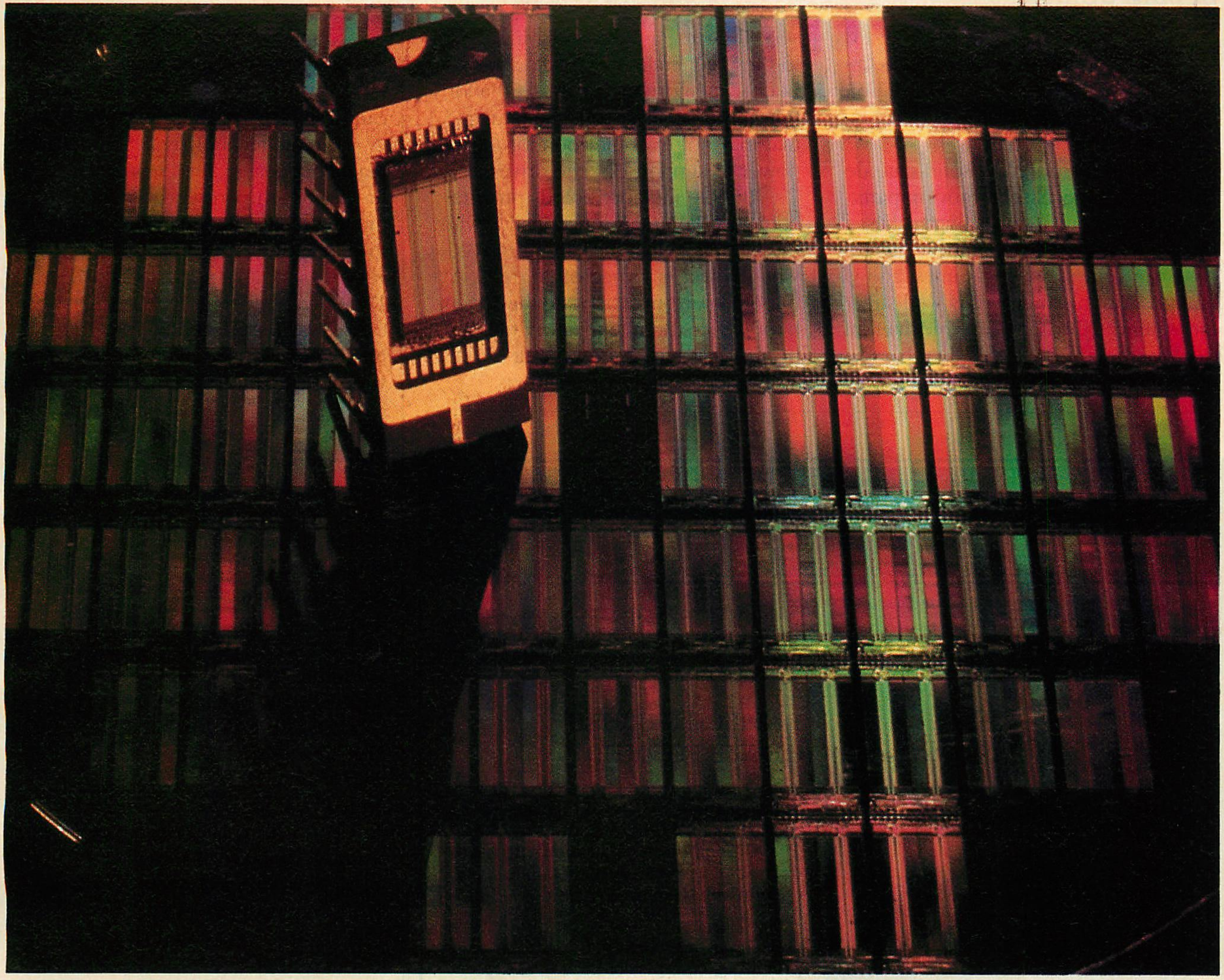

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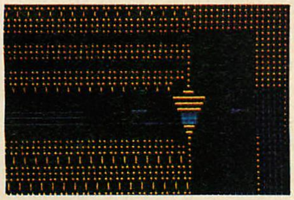


Bubble Boards

DON AWALT

The need for these expensive (but nonvolatile) bubble memory boards depends on the importance of your data.

Bubble memory technology has been a long time coming for any computer. From its loudly heralded origins in the sixties it has followed a wandering path to the marketplace, bedeviled by industry indifference and costs that failed to fall as quickly as those of RAM and rotating media storage. Several bubble memory products are now available for the IBM PC product line, and within those market niches in which nothing but bubble memory will do, the outlook for these products is decidedly bright.

The three bubble memory products that will be discussed here are the Helix PC Bubble Disk from Helix Systems and Development Corporation; the PDIB-512 Bubble Memory Board from Pure Data Ltd.; and the MBM-504 Bub-

ble Drive from HICOMP. All three boards have 512KB memory and occupy a single slot in the IBM PC; all use a bubble memory architecture that was developed by Intel Corporation.

Bubble memory is a solid-state device with no mechanical moving parts. Special component packaging makes bubble memory boards impervious to dust, dirty environments, fumes, and vibrations. Bubble memory is well suited for systems that cannot use mechanical storage devices, must exist in a harsh environment, or must have data preserved during a power loss. In addition to these general kinds of applications bubble memory can be a useful addition to portable personal computers that may not have the room or the power to support diskette drives.

Bubble memory boards provide enhanced RAM-disk functionality, with the advantage that files are preserved when power is turned off. If desired, a bubble board may become the system boot device. Bubble memory files may be write-protected, preventing unauthorized modifications or deletions.

Storage and retrieval of bubble memory data are faster than diskette but slower than fixed disk and significantly slower than RAM memory.

Bubble technology is an unusual magnetic means of storing data as a function of the presence or absence of moving magnetic domains in a thin magnetic film. The approach was invented by Bell Labs in the late 1960s. The first commercial bubble memory board was introduced by Intel in the mid 1970s. At that time, bubble storage was projected to be faster, cheaper, and denser (permitting more memory in a given printed circuit board space) than disk memory or RAM.

Several semiconductor manufacturers began producing bubble products. Computer and peripheral manufacturers announced products with bubble memory components. Prices failed to come down as rapidly as they did for disk memory and RAM. The perception that bubble technology offered few performance advantages at a higher price brought the growth of the bubble memory industry nearly to a halt. Products with bubble components were discontinued or upgraded to include more conventional components that offered a better price/performance ratio. Soon Intel alone continued development and production of bubble components.

Steady evolutionary (not revolutionary) improvements in density and considerable cost reductions in the last eight years have made bubble technology viable and marketable. Although the window for major market penetration in the mainstream of personal computing has been lost, a more specialized market may be emerging.

CHIP-LEVEL TECHNOLOGY

All three bubble boards tested use the same Intel chip design. Photo 1 (Pure Data's 512KB bubble board) shows four large square blocks on the board; these squares are Intel 7110 bubble memory units. Below each 7110 unit is a set of support chips that provides the computer interface to bubble memory itself.

Data are stored by the presence (representing a 1 bit) or absence (a 0 bit) of a magnetic domain (bubble) within a very thin, rare earth/iron oxide garnet film. The film has magnetic properties that determine the shape and movement characteristics of bubbles induced within it.

Bubbles are so named because in photomicrographs they look like spheres; actually they are cylindrical, equally wide and tall. Magnetic domains are regions of similar magnetic polarity

within a partially-magnetized region. A magnetically saturated film has one predominant magnetic domain. Nonmagnetized film contains domains existing at random three-dimensional positions. A thin film magnetized to a level less than complete saturation has a majority of domains oriented in a common direction; when the film is very thin (less than .001 inch thick), the possible orientations of the domains are reduced from three dimensions to a two-dimensional plane.

Magnetization of such a thin film with the proper crystallographic properties (for example, silicates such as garnet) at a level less than complete saturation creates isolated domains with one magnetic polarity within a larger domain with uniform and opposite orientation. The isolated domains that are created are magnetic bubbles.

Bubbles are nonvolatile because they are created by magnetization; electricity is not needed to preserve their existence. As a protective measure, bubble memory is packaged within a magnetic shield to filter any potentially disruptive external magnetic interference.

Bubbles must be moved to create and modify data patterns. Electric currents create magnetic fields that cause bubbles to move toward an opposite magnetic polarity, much as a magnet pulls an iron nail. Different magnetic fields are created using two electric coils that completely surround the garnet film, causing the bubbles to move through a modified region of the film that is shaped like a closed loop. Bubble and disk data both appear to move, but bubble data rotates on a stationary media, while disk media rotate carrying stationary data. The loss of electricity stops bubble movement and prevents further modification of bubble patterns.

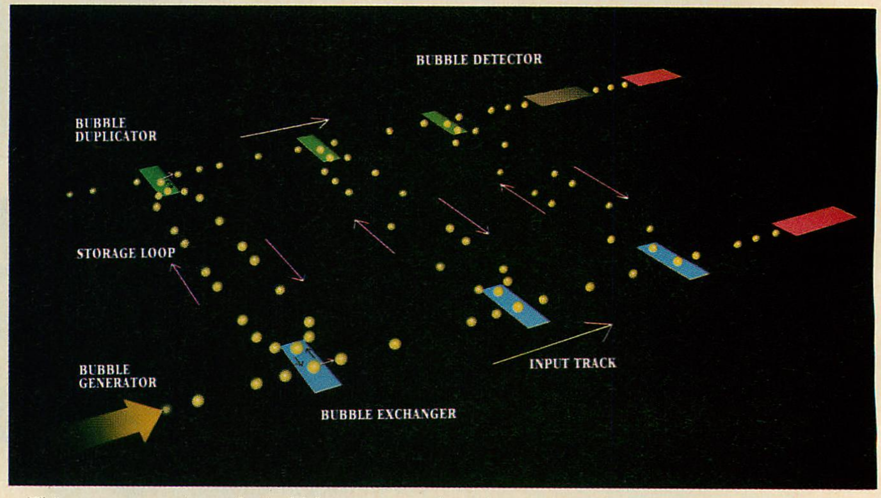
Bubble memory shares some I/O characteristics with disk drives. Both must deal with latency: bubble memory latency time is the time spent waiting for data to move into the proper loop position for replication to the input track (see below); disk latency is the time spent waiting for a disk platter to rotate desired data into position under the read/write heads before I/O transfer begins. Bubble I/O is done in blocks, as is disk I/O. Neither bubble nor disk data can be addressed on a byte basis.

Figures 1 and 2 shows the architecture of a bubble memory unit. Data move around the circular loops continuously, while the input and output tracks provide an access point and data channel to each loop for the reading and writing of data. The bubble detector senses the presence of bubbles during read operations and converts this information to an outgoing digital bit stream. The bubble generator converts incoming digital data patterns to patterns of bubbles during memory writes.

The bubble generator creates bubbles using a seed bubble, an oversized kidney-shaped magnetic domain. Through electrical excitation the seed splits into two parts. One part remains as the seed and quickly regains its former size and shape; the second part transfers to the input track as a bubble.

The seed resides on an easily magnetized alloy of nickel and iron. The magnetic field that is created by a local electric current, the currents rotating the nearby bubble data, and the shape of the electric conductor used to create the seed combine to maintain the seed's kidney shape.

FIGURE 1: *Bubble Memory Chip*



This representation of a bubble memory chip shows the relationship of the input track, output track, and several storage loops with bubble moving through them.

CIRCLE NO. 202 ON READER SERVICE CARD

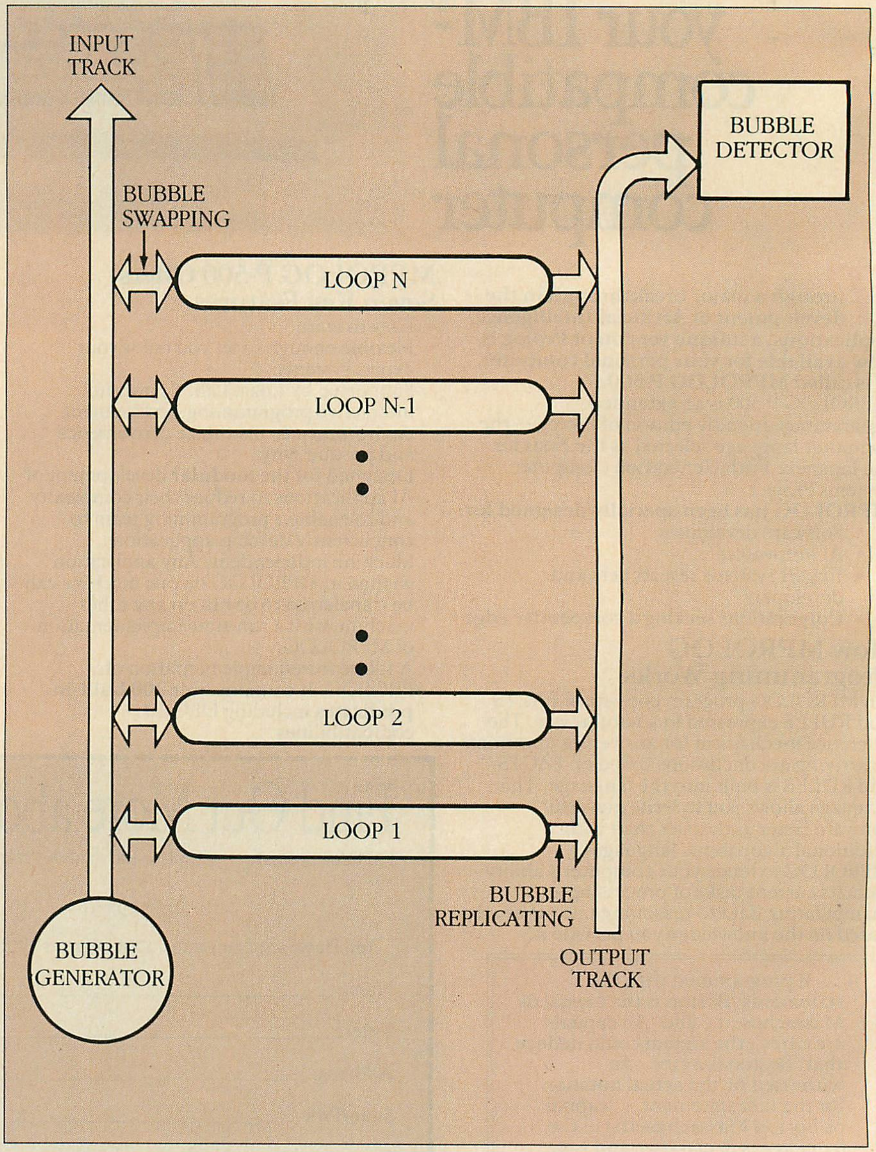
Data are written to bubble memory by timed, synchronous transfers of bubble patterns to the input track. A bubble generated onto the track represents a binary 1; to represent a binary 0, no bubble is generated for that time interval.

Writing a block of data to bubble memory takes several steps. Assume for the sake of explanation that the simple bubble memory system shown in figure 1 has 320 loops. (Actually, the Intel 7110 chip has its 320 loops distributed among four smaller sections to improve performance; see below.) Of the 320 loops, 256 are used for data transfer. One bit is transferred to or from each loop in one simultaneous transfer, for a total of 256 bits or 32 bytes.

First, 32 bytes of digital data are converted to a bubble pattern and written to the input track. The bubble pattern travels down the input track until each of the 256 bits is adjacent to one of the destination loops. The bubbles in the loops are moving continuously around the loops, so there may be a waiting period (latency) while the desired bubble position in each loop moves around to a position adjacent to the input track. When the proper position in each loop has rotated to the correct point, 256 bits (32 bytes) of data on the input track are swapped to bubble memory. Adjacent bubbles on the input track and the loops physically change places; it is not a copy-type operation.

The input track now contains 32 bytes of data that were swapped out of the loops. These bubbles continue to the physical end of the input track (the

FIGURE 2: *Bubble Memory System*



Data stored as bubble patterns move around the circular loops; the input and output tracks provide an access point and data channel for reading and writing data.

track is a unidirectional, noncircular, conductive medium), where they are magnetically destroyed.

This explanation of a bubble memory write assumes no spare loop tracking and 256 contiguous active loops. Spare loops are used when excessive loop errors are detected by the controller (a function identical to disk spare tracking); when the spare loops are present, the 256 active loops are no longer contiguous. Therefore, a pattern with more than 256 bits is generated with filler space appearing adjacent to inactive loops.

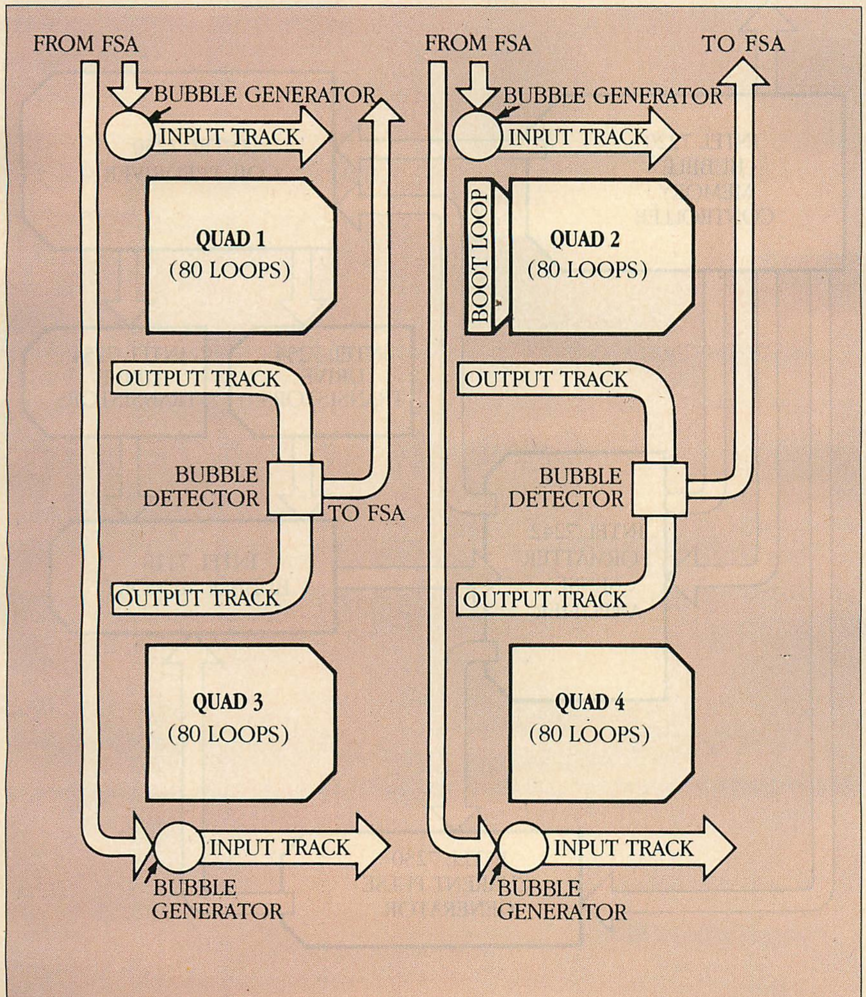
The read operation is similar, except that data are replicated (not swapped) from the bubble loops to the output track. The bubble detector converts the pattern to a digital signal.

The Intel 7110 bubble unit is a one-megabit storage device. Four of these units store four megabits of information organized as 512KB (see photo 1). Each of the 7110 units has 320 loops, with each loop holding 4,096 bits in a continually rotating bubble pattern. Of the 320 loops, 256 are used for data, 16 are used for error correction, and 48 are spares. A special "boot" loop records the active data loop locations, so that bad loops may be avoided.

To improve performance, the Intel 7110 is organized into four quads of 80 loops each. This arrangement shortens the length of the input/output tracks, reducing the amount of latency time during I/O. Figure 3 shows a diagram of the Intel 7110, with four quads, four sets of I/O tracks, two bubble detector units (that are shared by pairs of the quads), and the boot loop.

Bubbles move through their loops at the rate of 50 KHz, or 50,000 revolutions per second. The time required for a bubble to move from the bubble generator along the input track to a position adjacent to the proper loop, plus

FIGURE 3: *Intel 7110*



The Intel 7110 is organized into four quads of 80 loops each; this structure shortens the input/output tracks and reduces the I/O latency time.

the average rotational latency of bubbles on the loop, is 41 milliseconds.

Figure 4 shows a block diagram of the Intel bubble memory system used on each bubble board. The system consists of a 7220 controller, 7110 bubble unit, 7242 formatter/sense amplifier, 7230 current pulse generator, 7250 coil predriver, and two 7254 driver transistor assembly chips. Each 512KB board has four sets of chips.

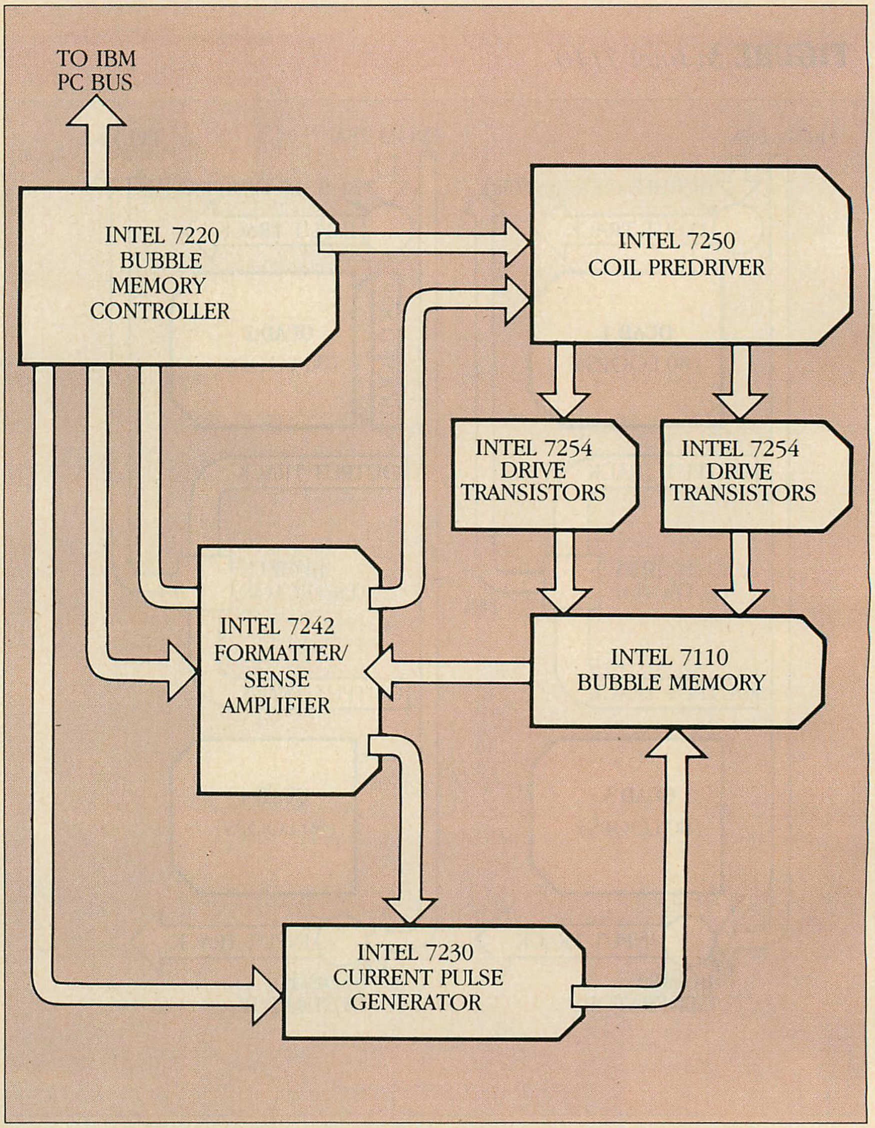
The Intel 7110 is a one-megabit bubble unit that contains bubble loops, I/O tracks, bubble detectors, and bubble generators. Also present is a magnetized field that is responsible for the shape and existence of bubbles on the film. In addition, the 7110 is enclosed in an integral shield that prevents external magnetic fields from corrupting its bubble-memory data.

The Intel 7220 bubble memory controller is the interface between the PC and the bubble subsystem. Sixteen controller commands (see table 1) provide I/O capability using direct memory access (DMA) for faster data transfer; many of the commands utilize a 40-byte FIFO buffer to send information to other chips in the bubble subsystem.

The third chip in the bubble memory unit is the Intel 7242 formatter/sense amplifier (FSA). The 7242 performs error-correction encoding and decoding, maintains spare loop information, and transfers data between the loops and the input/output tracks. The controller communicates with the FSA through the FIFO buffer.

The Intel 7230 chip is the current/pulse generator (CPG), which supplies current to split the seed bubble. The

FIGURE 4: *Intel Bubble Memory System*



The Intel memory system shown in this block diagram is used on each of the boards. A 512KB bubble board has four sets of chips, each storing 128KB.

TABLE 1: *Controller Commands*

COMMAND	FUNCTION
Abort	Terminates the command currently being executed by the 7220. Command is accepted only when the controller is in status *busy*.
MBM Purge	Clears 7220 internal registers, counters, and the magnetic bubble memory address RAM. Also determines how many 7242 channels are present.
Software Reset	Clears controller FIFO and registers except those containing initial values. Any 7242s present are reset.
Write Seek	Rotates the bubble memories to a designated page address location. No data transfer occurs. The command selects the page immediately prior to a page.
Read Seek	Rotates the bubble memories to a designated page address location. No data transfer occurs. The command selects the page immediately prior to a page.
Read FSA Status	8-bit status of 7242 (formatter/sense amplifier) chips is read and stored in the controller FIFO.
Read Bootloop Register	Bootloop Register of the selected 7242 channels is read and stored in the controller FIFO.
Write Bootloop Register	Causes the data pattern in the 7220 FIFO to be written to the designated 7242 bootloop register.
Write Bootloop Register	Same as Write Bootloop Register command, but Masked excess valid loops beyond 272 are not written.
Read Bootloop	Controller reads the bootloop from the selected bubble memory and stores it on the FIFO.
Write Bootloop	Existing contents of the selected bubble memory's bootloop are replaced by the new bootloop data contained in the 7220 FIFO. Encoding of the bootloop data is done by the controller.
Read Corrected Data	Controller reads into the FIFO a 256-bit block of data from the FIFO of each 7242 channel after an error has been detected. Data are cycled through the error-correction network and transferred to the controller. The 7242 then reports to the controller if the error was recoverable.
Read Bubble Data	Data are read from bubble memory into controller FIFO. Starting location and transfer length are defined in parametric registers of the controller.
Write Bubble Data	Data are read from controller FIFO and written to bubble memories. Starting location and transfer length are parametric registers.
Initialize	Controller determines number of 7242 channels present, reads and decodes the bootloop from each bubble memory, and stores the data in the corresponding 7242 bootloop register.
Reset FIFO	Controller's FIFO area is cleared.

Many of the Intel 7220 controller commands shown here utilize a 40-byte FIFO buffer to send information to other chips in the bubble subsystem.

CPG also initiates the swap and replicate functions that take place between the input/output tracks and loops.

Two other types of chips complete the Intel bubble memory subsystem. The 7250 coil predriver and 7254 quad drive transistors drive two coils positioned at right angles to create an electromagnetic field that causes the bubbles to travel through the loops. One 7254 is required for each of the coils.

The ruggedness of bubble boards surpasses that of most other boards. Based on Intel specifications, the bubble chip operates at a temperature of 150 degrees Celsius for 168 hours with no failures, endures 100 temperature cycles of −65 degrees Celsius to 150 degrees Celsius with a failure rate of 1.5 percent, and withstands shocks of 200 Gs and severe vibrations of 2 Hz to 2 kHz at 20 Gs, with no failures.

PC BUBBLE MEMORY

The three bubble boards reviewed here are similar in appearance. In addition to the four Intel bubble chips, each board contains support circuitry, configuration

uration switches and/or jumpers, and an EPROM (Electrically Programmable Read-only Memory) chip with software to interface the bubble device with DOS and service system interrupts directed to the bubble board.

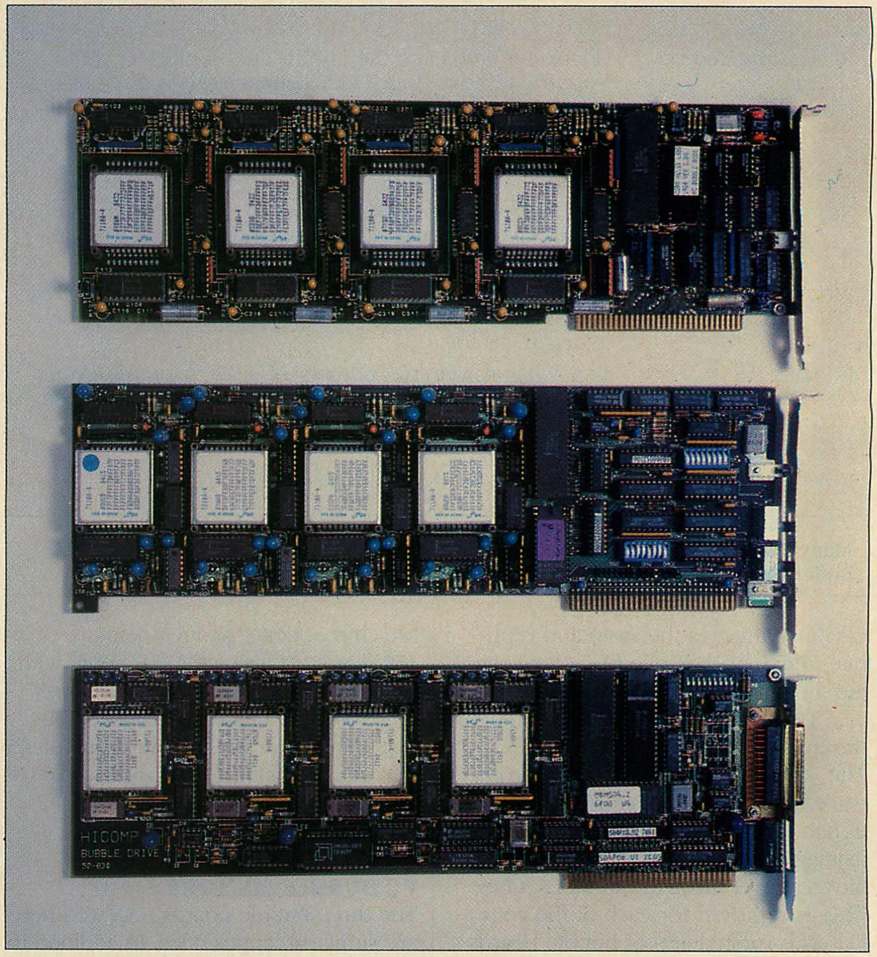
Many PC boards require EPROM code for proper operation; in addition to bubble boards, the new IBM Enhanced Graphics Adapter, Fixed Disk controller, SNA, and other communications boards need EPROM code. The software contained in EPROM is similar to software contained in the IBM BIOS, and in some cases, on-board EPROMs replace BIOS routines (the Enhanced Graphics Adapter EPROM replaces several BIOS routines). In other cases, EPROMs create interrupts or other links to the IBM PC system.

A feature called *ROM scan,* which is integrated into IBM BIOS chips manufactured after 10/27/82, enables EPROM programs and the hardware they service to be used by applications programs without requiring that driver programs be run when the PC is restarted. ROM scan examines addresses in the range C8000 to F4000 in search of EPROM software. The scan routine recognizes EPROM software when it finds a word of 55AAH on a 2KB boundary, and the EPROM program passes checksum verification, using the third byte of the program as a length indicator. The system uses the fourth byte as the address of a subroutine to be executed on system power-up.

The bubble boards provide configuration switches for determining the EPROM address; the documentation also describes how to use the DOS DEBUG program to select an address space not being used by another board.

The manuals for Helix's and HICOMP's bubble boards describe how to determine whether ROM scan is available in the PC's BIOS (Pure Data's manual did not). If an old version of the IBM BIOS chip is present, Helix and HICOMP boards require that a supplied software program be used after every system restart for the bubble drive to be recognized. Pure Data's board does

PHOTO 1: *Pure Data 512KB Board*



The four large square blocks are Intel 7110 bubble memory units. Below each unit is a set of support chips that interfaces to bubble memory.

PHOTOGRAPH • STEVE BORNS

not provide software to emulate ROM scan and recognize the bubble board, so the new BIOS chip must be installed.

All PC/XTs and PCs with 256KB motherboards should have the correct ROM BIOS, so users with these machines may be able to assume their BIOS has the ROM scan provision. (However, ROM chips may be plugged into a motherboard of any configuration, so users would be wise to check.) DEBUG can be used to look at location $FFFF : 5; the BIOS version date stored there should be 10/27/82 or later.

Each of the three boards requires that configuration information be set through switches on the board. Documentation describing switch-setting for each is straightforward and each board functioned correctly when properly installed.

Ease of installation notwithstanding, the boards have too many switches. The Pure Data and HICOMP boards have 18 switches and the Helix has eight jumpers and one switch. The configuration process needs simplification; an easier approach would be to remove the switches and prompt the user for configuration information that is saved in bubble memory. Many users will have trouble making a large number of configuration decisions through board-level switches; if the user makes a mistake or wants to change the way he operates a board, he must open the PC's chassis.

Generally, the documentation that is included with the boards is poor. HICOMP's manual consists of stapled sheets in letter-quality print format. The Pure Data product summary sheet describes documentation as being in "IBM 3-hole binder format," although the package contains a photocopied, reduced-size spiral-bound manual. The Helix manual is professionally bound, but the type quality is mediocre.

Only one problem arose during installation of the bubble boards. The Pure Data board initially did not operate as a diskette drive, and the system did not acknowledge the presence of two diskette drives on the PC/XT. This problem was the result of an error in documentation: the manual did not cite the need to update the switch on the IBM System board that specifies the number of diskette drives on-line.

The only clue to this problem is buried in an appendix of the Pure Data manual that describes error messages and their causes. This lack of information is a serious omission, because users may not remember that the IBM PC has a switch for the number of diskette drives and they probably will not automatically read an appendix chapter of error conditions.

Each board emulates a diskette drive; the Helix board also emulates a fixed drive. Pure Data has announced that a future release of its board will add fixed-disk emulation. Up to four Helix boards can be installed per IBM system, as long as ample power and expansion slots are available, but the PC can support only one of the HICOMP and Pure Data boards.

The Pure Data board offers fast-speed mode to optimize performance and slow speed (at one-half the speed of fast mode) to minimize power consumption. The documentation recommends slow speed for "heavily loaded expansion slots in portable PCs." Slow-speed mode performs two serial transfers of data from the four 7110 units, whereas fast-speed mode transfers in parallel from all four units.

The operational speed of the three boards is different. William Hunt's benchmarks (see "Fixed-disk Benchmarks," *PC Tech Journal,* November 1984, p. 64), summarized in table 2,

TABLE 2: *Benchmarks*

	HELIX	PURE DATA (fast mode)	PURE DATA (slow mode)	HICOMP
SECTORS PER BOARD	968	708	708	1,010
SEQUENTIAL READ				
1 sector	.022 second	.022 second	.036 second	.025 second
8 sectors	.126 second	.129 second	.247 second	.132 second
16 sectors	.247 second	.250 second	.489 second	.255 second
24 sectors	.371 second	.371 second	.728 second	.376 second
RANDOM READ				
1 sector				
.10 width seek	.052 second	.052 second	.100 second	.096 second
.33 width seek	.052 second	.093 second	.100 second	.096 second
.50 width seek	.052 second	.054 second	.060 second	.055 second
.90 width seek	.052 second	.092 second	.037 second	.096 second
8 sectors				
.10 width seek	.187 second	.148 second	.291 second	.192 second
.33 width seek	.148 second	.187 second	.291 second	.190 second
.50 width seek	.187 second	.148 second	.250 second	.190 second
.90 width seek	.187 second	.187 second	.247 second	.190 second

The Helix board is faster than the Pure Data board in fast mode. The HICOMP board comes in third; the Pure Data board is the slowest of the three in slow mode.

measure the relative performance of the bubble boards. The Helix board is marginally faster than the Pure Data board in fast mode, with the HICOMP board coming in third. The Pure Data board in slow mode is the slowest performer.

Other features are unique to individual boards. The Helix board has an on-line/off-line switch located on the back of the board that is accessible when the PC is operational. Helix offers board compatibility with Softech Pascal IV.13 and CP/M-86, in addition to MS-DOS support. All three boards are compatible with MS-DOS 2.0. HICOMP is the only board that does not work with MS-DOS 3.0; under 3.0, the HICOMP board causes the PC to hang indefinitely when bubble memory is read, thereby requiring a reboot.

A unique feature of the Pure Data bubble board is password protection, which prevents unauthorized access to the bubble drive or the entire PC system, based on the user's choice. Password capabilities are enabled through the setting of a board-level switch. Two passwords are available: the master password authorizes system access and the changing of master and user passwords, and the user password merely grants access to the system. Another board-level switch is set to force access to the master menu, to change passwords, and to perform other master access functions. Proper password entry also requires that the user type each letter in the password correctly; he has five attempts to get it right.

The password feature offers five modes of password protection: password protection is disabled; password entry is required on power-up and system reset—otherwise, system access will be denied; password entry is required on power-up—otherwise, system access will be denied; password entry is required on power-up and system reset—otherwise, access to the bubble drive is denied; and password entry is required on power-up—otherwise, access to the bubble drive is denied.

The Pure Data board formats its diskette drive emulator with 360KB, an exact emulation of an MS-DOS floppy diskette, but one that also entails a waste of approximately 152KB of bubble memory. The Helix and HICOMP boards emulate diskette drives of 512KB and waste nothing in the process.

DISKCOPY and DISKCOMP are the only MS-DOS disk-related commands not supported with the Helix and HICOMP electronic disk emulations; Pure Data supports all commands. (Note that the Helix board is a fixed-disk emulation, which should not support these commands; the HICOMP diskette-drive emulation should.)

The three boards reviewed here are very similar. Future market differentiation in bubble memory boards will involve added software, add-on functions, price, or higher performance bubble units (which already exist). The Pure Data board offers poor documentation and a 360KB format that wastes about 152KB of memory. It did, how-

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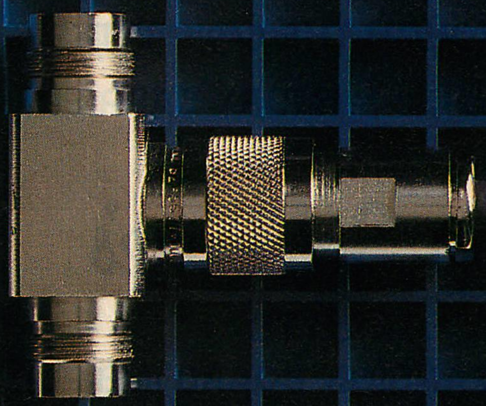

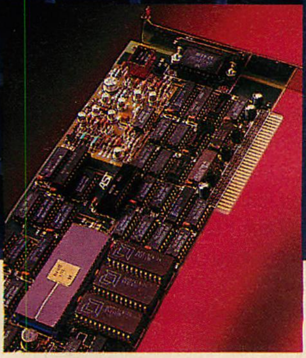

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ever, run a close second in the test for speed and it costs $500 less than its competitors. The HICOMP board is the slowest performer and is not compatible with DOS 3.0. (A revision should solve this problem, but HICOMP has not announced any revisions.) Testing of the Helix board revealed no major problems. Its documentation and performance are the best currently available—although the documentation could be improved—and it has the advantage of allowing four boards to be installed in a single PC.

At one time, bubble memory subsystems were prohibitively expensive. It would have been difficult to justify the cost of a bubble unit even two years ago. Now, although bubble boards are still expensive—especially compared to the 20MB fixed disks that are available for less than $1,200—a case can be made for their inclusion in systems that must endure environmental conditions that might destroy moving media.

The case for using bubble memory in portable computers is less clear, especially with the cost of CMOS RAM going down every month. It is important to remember, however, that loss of the lithium battery that keeps CMOS RAM alive translates into loss of data; on the other hand, no matter what the state of the power system is, bubble memory always keeps data alive. If the data are sufficiently important, that may be justification enough for investing in bubble memory.

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Intel BPK 72 Bubble Memory Prototype Kit Users Manual. Santa Clara, CA: Intel Corporation, October 1984.

Intel Memory Components Handbook. Santa Clara, CA: Intel Corporation, December 1984.

Helix PC Bubble Disk (512KB): $1,495
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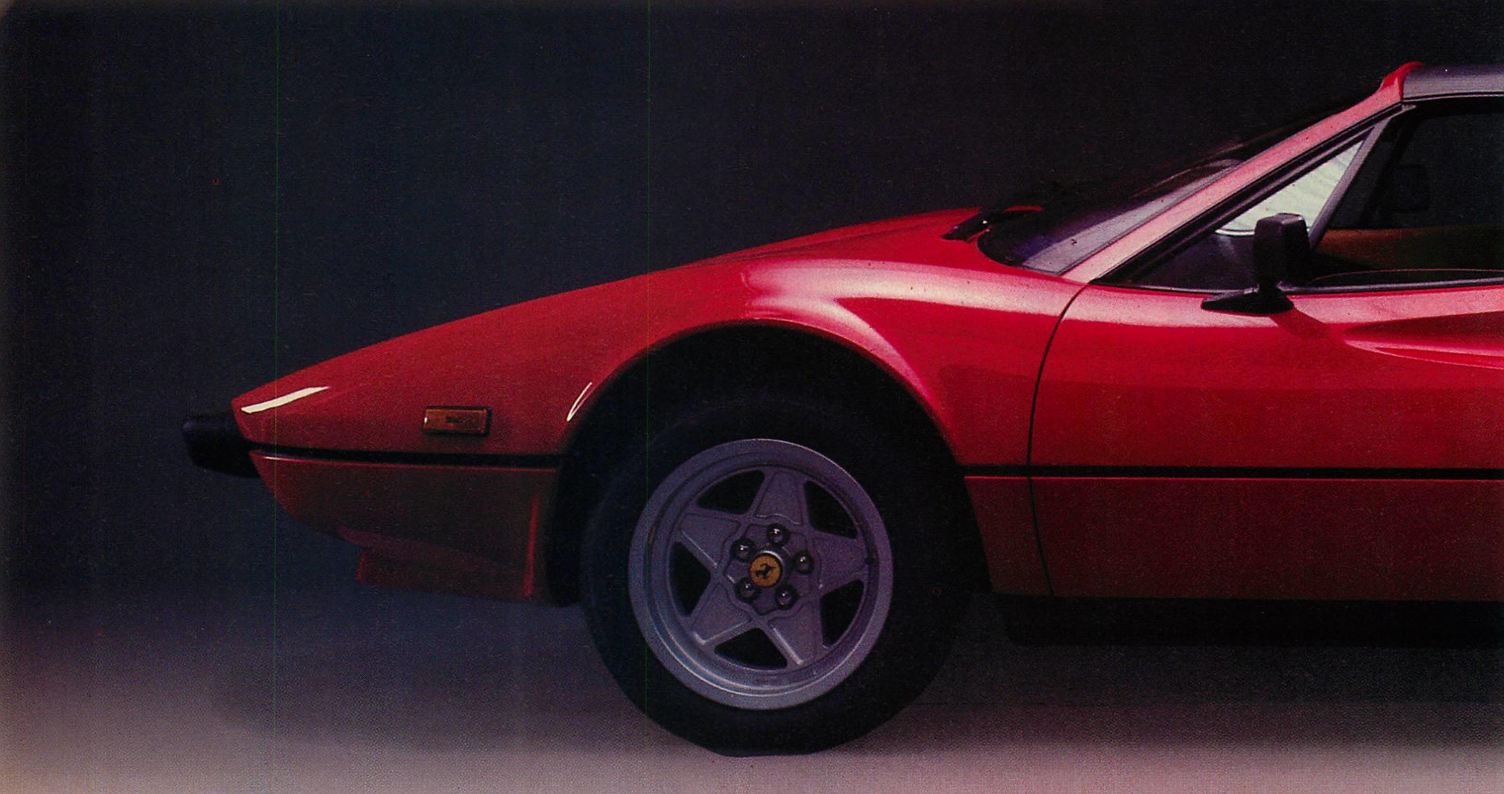

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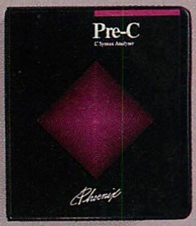

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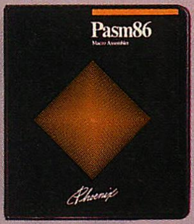

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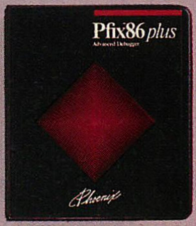

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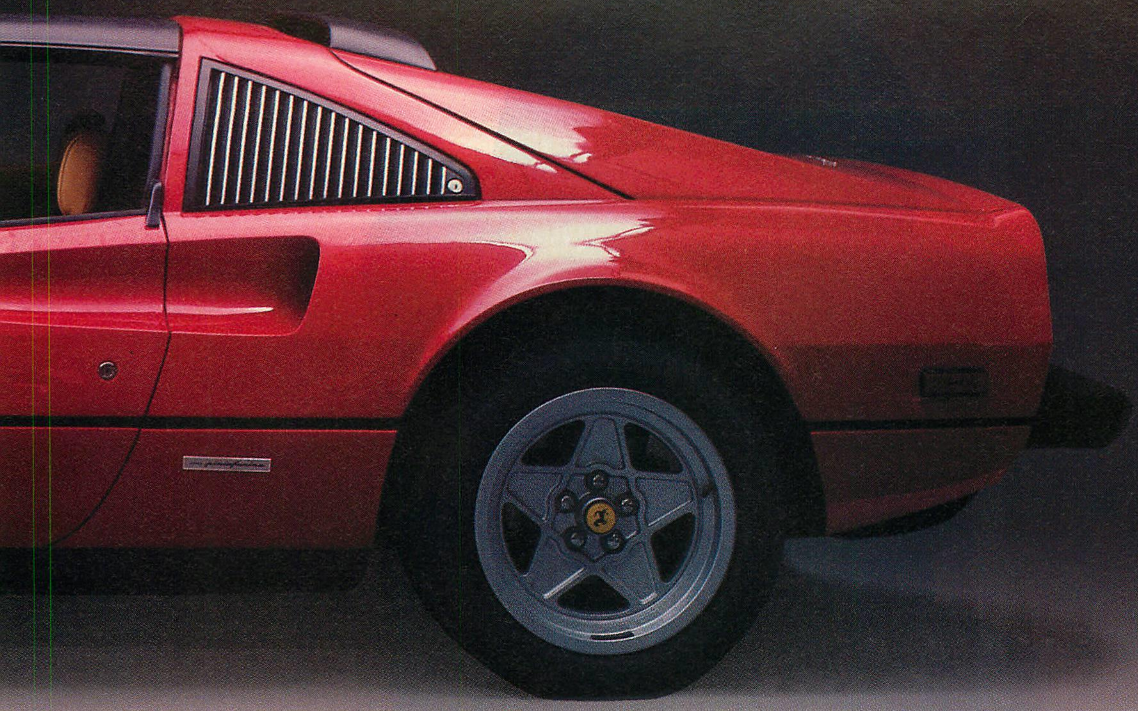

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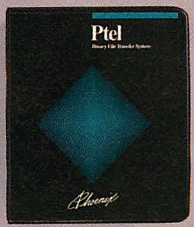

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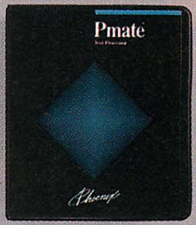

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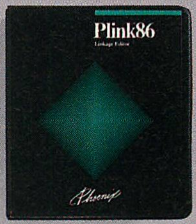

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Testing 1, 2, 3, 4, 5

New diskette-drive testing programs help users avert problems in read-write operations.

One of the most unnerving moments in the life of a computer user is when he becomes distrustful of diskette drives. Imagine a couple of possible situations:

The professional user of an IBM PC/XT writes a file onto a floppy diskette to take with him for further work on his PC*jr* at home. Once at home, however, he finds that the *jr* is unable to read the diskette: a defective drive (its heads are out of alignment) on the XT writes data that it can read, but that other computers cannot. Or . . .

A purchasing manager who has been carefully backing up all of her vendor correspondence on her XT has had increasing difficulties in reading the back-ups. But she puts off having the drive checked out. Then, someone accidentally reformats her fixed disk, wiping out all the correspondence. No problem. She decides to get the floppy drive repaired while the system is down and then restore the back-ups. When the computer comes back, however, none of the back-up diskettes can be read on the repaired drive, even though it is the same drive that recorded the files in the first place.

Users who are unscathed in these kinds of catastrophes are fortunate, but they should be aware that the time to take preventive measures is before the problem occurs, not after.

Deciding when a drive needed adjustment used to involve much guesswork because some of the tolerances have to be read to 5/10,000ths of an inch and they cannot be seen readily or measured mechanically. The modern 5¼-inch floppy diskette drive and the media that it uses are very forgiving; they allow for the widest possible variations in diskette drive adjustments. By keeping the information density to a conservative 360,000 bytes per two-sided floppy, fairly loose tolerances can be allowed. If, for example, the density were increased to 2 million bytes of information on the same diskette, the adjustments would have to be much more carefully controlled. The effect of the low recording density is that the adjustment quality of the diskette drive is, for the most part, ignored.

Five new diskette-drive testing programs allow users to check the adjustment of their diskette drives. The products offer a wide range of capabilities and varying degrees of ease of use. If the two users mentioned at the beginning of this article had tested their drives with one of these programs, they

JAMES CHUMBLEY

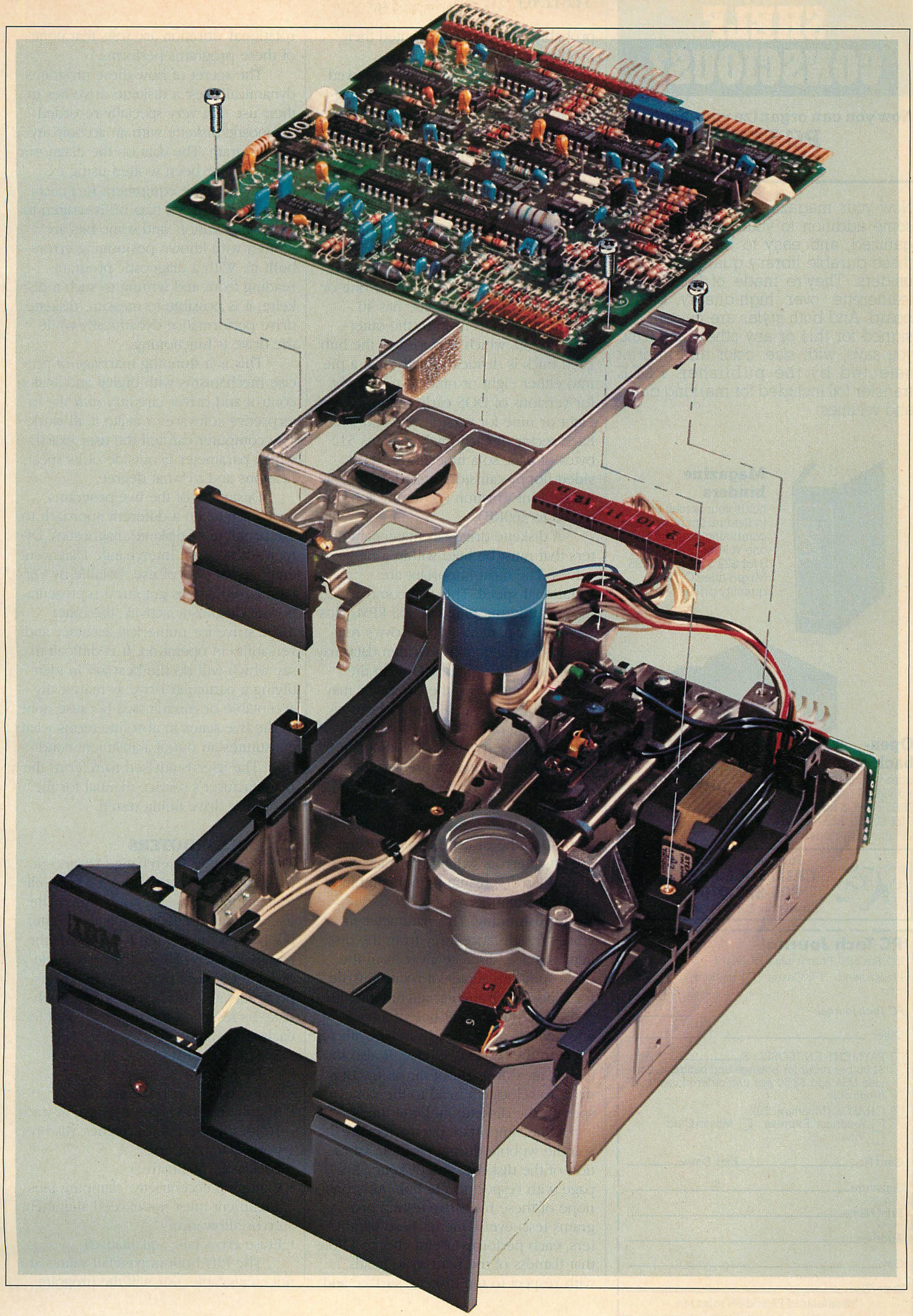


ILLUSTRATION • JOE LAPINSKI

probably could have prevented their problems from ever occurring.

The diagnostic packages reviewed here are: Recording Interchange Diagnostic (RID) by Dymek Corporation, Datalife Disk Drive Analyzer by Verbatim Corporation, Interrogator by Dysan Corporation, Memory Minder by J. & M. SYSTEMS, LTD., and ReadiScope by ReadiWare Systems, Inc.

Drives work by spinning the floppy diskette around a hub and accurately positioning the read/write heads above and below. A diskette has either one or two usable sides. Each side has 40 tracks, numbered from 0 (the outermost) to 39, which is closest to the hub. Each track is divided radially, like a pie, into either eight or nine sectors: eight for versions of DOS earlier than 2.0 and eight or nine for versions 2.0 and later. Each sector of each track contains 512 bytes of data, so a nine-sector, dual-sided floppy can store a total of 368,640 bytes of information (generally approximated to 360KB).

A diskette drive has many parameters that must be held within a range of values. The most important are:

Rotational speed. This is recommended to be within the range of 300 RPM, plus or minus 2 percent. If the drive's rotational speed is too fast, written data may be elongated on the track or, in the most extreme cases, the computer may not be able to write all the bits onto a track during one rotation. Conversely, if rotational speed is too slow, the data written will be too compressed for other computers to read.

Centering during clamping. Misadjustment here will cause a circular track to wobble as the diskette rotates. Clamping offset errors will add to track positioning errors, resulting in a combined track alignment error.

Head positioning. This parameter includes the distance away from the diskette surface, distance away from the drive spindle's center of rotation (true track position), angular alignment with respect to the tangent line of a track, and flatness of the head surface with respect to the diskette surface. It also includes measurement of the ability of a drive to relocate a head to the same spot on the diskette multiple times.

Other important parameters are spindle wobble during rotation, vibration of the diskette, and diskette slippage with respect to the hub. Although none of these five drive-testing programs tests every one of these parameters, each performs useful checks. (Note that flatness of the read/write heads with respect to the diskette surface and rotational vibration are tests that none of these programs performs.)

The secret of how these programs dynamically test a diskette drive lies in their use of a very specially recorded diagnostic diskette with an accompanying program. The data on the diagnostic diskette have been written using extremely accurate equipment in a clean environment. Each data bit is written to a known location, and some bits are written with known positioning errors built in. With a diagnostic program reading from and writing to such a diskette, it is possible to measure diskette drive performance dynamically while the drive is functioning.

This is a stunning marriage of precise mechanisms with digital and analog control and driver circuitry *and* the interpretive software to make it all work. The computer can tell the user exactly which parameter is outside of its specifications and to what degree.

Designers of the five programs have each taken a different approach to the problem of diskette diagnostics: Dymek's Recording Interchange Diagnostic emphasizes ease of use; Datalife by Verbatim emphasizes graphical representation of diagnostic activity; the other three strive for numerical accuracy and versatility in operation. It is difficult to say which will do the best job in identifying a particular drive as marginally acceptable or misadjusted because none of the five states in absolute terms what constitutes an out-of-adjustment condition. The user is advised to refer to the manufacturer's service manual for the particular drive being tested.

TROUBLESHOOTERS

The Recording Interchange Diagnostic (RID) program is the easiest to use; all tests are performed automatically. The user simply installs the single diskette, boots the system with it, and reads the results of each of seven tests. A single diskette contains both the diagnostic programs and the precisely recorded data. Its tests and the limits allowed for each are as follows:

- Speed: 300 RPM +/− 2 percent
- Noise tolerance: (qualitative)
- Write/read: 0 errors, track 34
- Alignment: 0 errors with head at track 16 location +/−0.002 inches. Also reports clamping error.
- Backlash: (qualitative)
- Clamping eccentricity: clamping plus alignment must not exceed alignment error allowance.
- Erase cross talk: (qualitative)

The RID built-in pass/fail values are not changeable, nor will the program

report any results quantitatively, except rotational speed. Once the program is started, it runs all seven tests automatically (it will not run just one test). The program changes the display mode to 40 columns on the Color Graphics Adapter, which can be distracting. See photo 1 for the pass/fail summary provided by the program.

The program does not print out the diagnostic information by itself; however, since it runs under DOS, pressing Ctrl-PrtSc will successfully write the screen output to the printer, providing the user with a printed record of the diagnostic results.

The principal advantage offered by this program is that it is quick and easy; its main disadvantage is that its output is only qualitative. In addition to the one-page instruction and specifications card, the package includes a 16-page information brochure (printed on three-by-five-inch pages) describing the tests. The program has no licensing restrictions that might prevent its use on more than one computer. RID best serves the user who wants only a quick, pass/fail evaluation of a diskette drive, and for whom graphics and numerical data are not a necessity.

The product by Verbatim, the Datalife Disk Drive Analyzer, also contains its program and precision-recorded diagnostic data tracks on a single diskette. It runs four tests—radial alignment (true track positioning), speed, clamping eccentricity, and write/read—but the user is not informed of the allowed limits. The results are reported as good/fair/poor, but quantitative measurements of drive parameters are not given, nor can the user set or change the program's pass/fail values.

The program includes an autotest option that will run the four tests automatically. Although the program will not print out the information, pressing Shift-PrtSc when the autotest is complete will capture the above diagnostic results onto paper.

A noteworthy feature of the Datalife Disk Drive Analyzer is its excellent use of animated graphics, which depict disk operation during the individual tests. (Photo 2 shows the radial alignment portion of the autotest in progress.) The graphics run only in black and white and provide no numerical data concerning the tests.

The package does not include a manual: all documentation is on a single instruction card. As with RID, this program has no license restrictions to prevent its use on more than one computer. Verbatim's offering is for the user

who will trade a precise understanding of the product's test criteria for the opportunity to watch a graphic representation of the drive as it is being put through its evaluative paces.

The Interrogator by Dysan Corporation is a serious diagnostic tool that runs five tests:

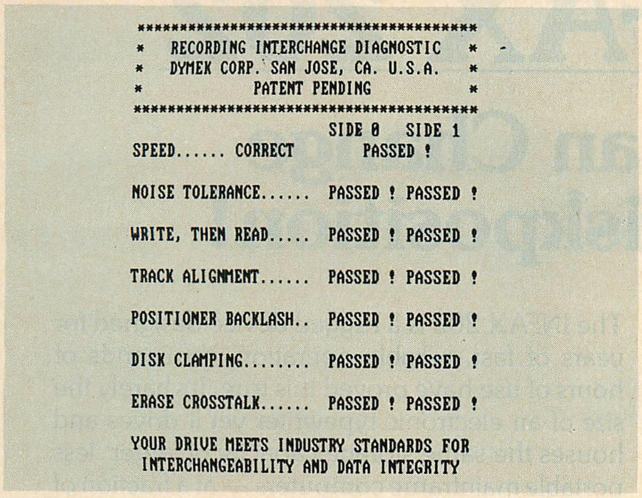
- Speed of rotation: 300 +/− 6 RPM
- Centering eccentricity: +/− 0.007 inch
- Radial offset from track nominal center: +/− 0.008 inch, and positive and negative offsets must not vary by more than +/− 0.004 inch
- Azimuth alignment—must read data known to be misaligned to the track tangent line by +/− 42 minutes of arc with no errors
- Hysteresis (positioning repeatability): +/− 0.003 inch

Test results are reported both qualitatively (pass/fail) and quantitatively, with actual measured values for the various parameters. Photo 3 shows the display from the spindle speed test. The user has the option of using Dysan's preset recommendations for pass/fail limits or, if his disk drive's service manual specifies others, he can modify Dysan's limits to match his own hardware. Although Dysan's limits are not claimed to be in compliance with any manufacturer's specifications, Dysan states that the limits it has selected "work well on the machines we have tested."

The testing material for this product comes on two diskettes: one contains the program; the other, called the DDD (Digital Diagnostic Diskette), contains the precision data. In addition to the five tests run with the DDD, the program can support read/write tests to a normal floppy diskette. When used with a Dysan Analog Alignment Diskette (not included with the program), manual seek to any track is provided in the program utilities. This program will produce hard-copy records of the diagnostic results, but it supports only a parallel printer (and since it does not run under DOS, printer output cannot be redirected to either serial port). It is the only product that will run in color as shipped from the factory.

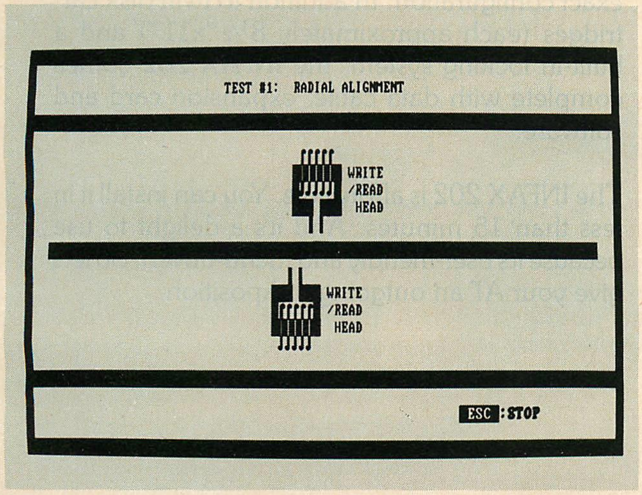
One serious failing of the Interrogator is that even though it resides on a non-DOS boot disk, an XT may not boot the program successfully if DOS can be booted from drive C: instead. If a user's XT normally boots from C:, he must first either erase or rename COMMAND.COM on drive C:. (On my system it is necessary to boot from a floppy diskette containing DOS and restore COMMAND.COM to drive C: after each running of the Interrogator.)

PHOTO 1: *RID Test Summary*



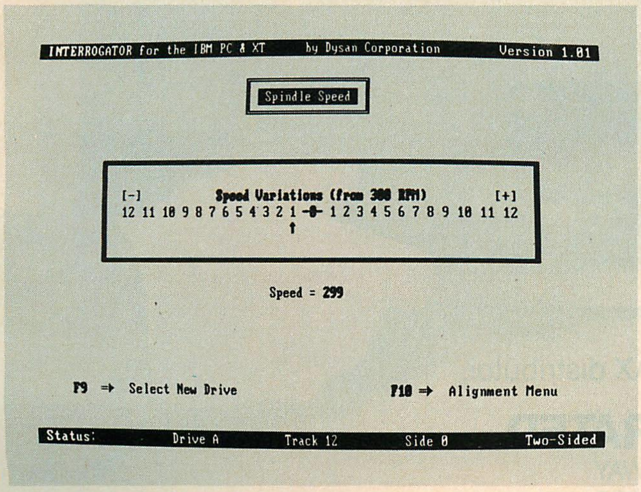
RID does not provide quantitative results on its tests, but indicates only whether a drive is acceptable.

PHOTO 2: *Verbatim Radial Alignment Test*



Two head figures move independently across the disk.

PHOTO 3: *Interrogator Spindle Speed Test*



The arrow indicates current spindle speed value.

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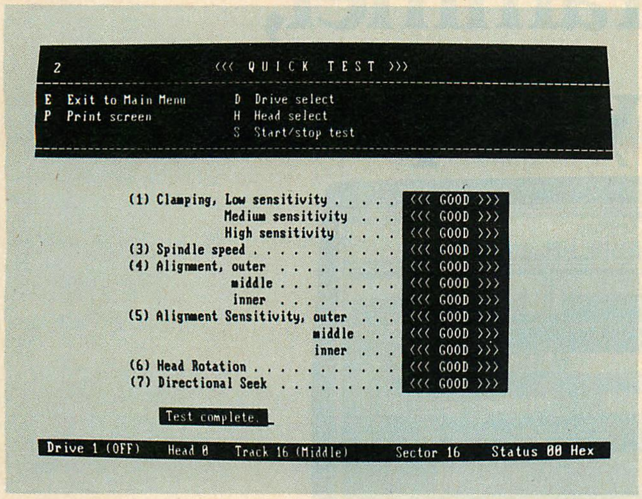
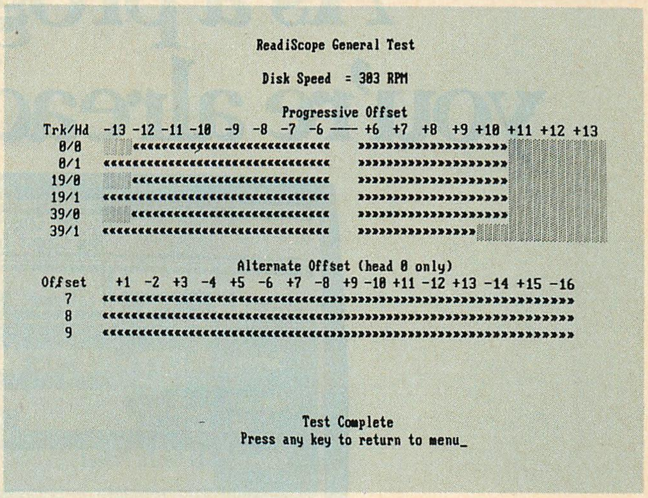
PHOTO 4: *Memory Minder Quick Test Summary*



Memory Minder's Quick Test gives a pass/fail evaluation of the drive; individual tests report quantitative results.

PHOTO 5: *ReadiScope General Test*



The progressive offset results show a slight misadjustment. A perfectly aligned drive would have a symmetrical pattern.

The package comes with an excellent 58-page manual that explains in detail the function of each of the tests, the values of the limits for the parameters being tested, and how to choose and enter replacement values for the limits. Superb diagrams and simulations of the CRT display output are included. The user need not have a technical background in order to understand the manual. The program does not run under DOS, so it cannot be run on PC*jr*, but a user with a PC or PC/XT might select the Interrogator for its ease of operation and its ability to report both numerical and pass/fail results.

Memory Minder by J. & M. SYSTEMS, LTD. provides the most detailed information of all five systems, but is the most difficult to use. It does not allow changing of the good/fair/poor limits for its automatic test mode, and its individual tests do not report pass/fail results, but require interpretation of the numerical values that are displayed or printed. Furthermore, the values for the limits used by the automatic test cannot be clearly discerned from the program manual. The individual tests all run continuously—the user must terminate each one manually.

This product is contained on two diskettes, one of which is a Dysan DDD. In its Analog Alignment Aid mode, which is not a test but a positioning aid for use with an alignment diskette (not included in the program) and an oscilloscope, the program allows manual positioning of the read/write heads to any track on either side. The tests supported by Memory Minder are:

- Clamping eccentricity
- Rotational speed
- Drive sensitivity to head misalignment
- Radial alignment to true track position
- Head rotation off track tangent line
- Directional seek or hysteresis (head respositioning error)

This system outputs numerical data from the individual tests, good/fair/poor information from the automatic test, and a graphical depiction of the results. The screen summary of Memory Minder's "quick test" is shown above in photo 4. It is also the only one of the five products that supports both a parallel and a serial printer for printing of diagnostic results. Its accompanying 42-page, 8½-by-11-inch manual is quite good: it explains all operational aspects of the program and provides an explanation of disk drive operation, as well as a summary of diagnostic approaches to the problems of drive adjustment. The manual is not typeset, however, and is somewhat awkward because of its large size and lack of a vinyl binding.

Memory Minder is not restricted by license agreement to one single computer; for this reason, it will be the program of choice for drive technicians and computer repair operations.

The ReadiScope diagnostic package by ReadiWare Systems comes on two diskettes and, again, one is the Dysan DDD. But unlike the other two packages that use the DDD, the ReadiScope system requires that the serial number of the program diskette and that of the DDD match, otherwise an error message will be displayed. The program does not run in color as shipped from the factory; however the manual includes an explanation of how to patch it for operation in color using IBM's DEBUG. The *Technical Reference Manual* must be consulted to select the color attributes that are inserted in place of the values; this is not a job for a casual user. The tests that are run by ReadiScope include:

- Speed of rotation
- Progressive offset (true track position)
- Alternate offset (hub eccentricity and track centering)
- Azimuth rotation (head misalignment to the track tangent line)

Both graphic and quantitative results are displayed, but no pass/fail limits are given, and none can be set by the user. The user can request a sample display of the graphic output that might be expected from either a properly adjusted or a problem drive; this display can be compared with the display from the actual drive under test to determine if adjustment or repair is required. Photo 5 shows a typical display of the ReadiScope general test. If the manufacturer's technical specifications for the drive are available, the numeric output from the program can be used to determine quantitatively whether or not a parameter is within the manufacturer's specifications.

No direct printer support is available from the program, but because ReadiScope runs under DOS, Shift-PrtSc will output the diagnostic measurements and graphic screen displays to a printer. An extensive 53-page manual explains program operation and diskette drive theory, including an outline of drive repair and diagnostic techniques. The manual also includes several figures representing its screen outputs, and ReadiScope's is the only manual with drawings of diskette drives that show the locations where adjustments

TABLE 1: *Comparison of Features*

	SUPPORTS COLOR	GRAPHICS DISPLAY	USES PC-DOS	USES DYSAN DDD	GIVES QUANTITATIVE	RUNS ON PC*jr*	SERIAL PRINTER	PARALLEL PRINTER	AUTOTEST CAPABILITY	PAGES IN MANUAL	EXPLAINS DRIVE OPERATION	USER-SETTABLE PASS/FAIL VALUES	HELP SCREENS	MANUAL SELECTION OF HEAD AND TRACK	READ/WRITE TO NORMAL FLOPPY
RID (DYMEK)	No	No	Yes	No	No	No	No	No	Yes	1	No	No	No	No	No
DATALIFE (VERBATIM)	No	Yes	No	No	No	No	No	No	Yes	1	No	No	Yes	No	No
INTERROGATOR (DYSAN)	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	58	Yes	Yes	No	Yes	Yes
MEMORY MINDER (J&M)	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	42	Yes	Yes	No	Yes	No
READISCOPE (RSI)	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	53	Yes	No	No	No	No

Clearly, the RID and Datalife products are "early warning" devices that alert a nontechnical user to a potential problem; the other products, however, can be used to assist the actual adjustment of diskette drives.

are to be made. The manual is not typeset, but it is contained in a standard vinyl folder that is the same size as most other IBM-family programs.

ReadiScope is the only program that can be run on the PC*jr*, which indicates that it probably is, by IBM's own definition, a well-behaved program, one that uses only the DOS function calls and does not write directly to either the display buffers or to the diskette drive controller. This program should interest users who are willing to dig out the manufacturer's pass/fail limits for their drive's parameters, or those who own a microcomputer that is almost PC-compatible (like PC*jr*).

DO-IT-YOURSELF ADJUSTMENTS

Some brave users might attempt to make disk drive adjustments by themselves, although this is generally a job better left to a trained professional. At the least, a competent (and determined) user must have a copy of the drive's factory service manual in hand. ReadiScope and Memory Minder are the only two programs with documentation that includes discussion of drive adjustment techniques (Memory Minder does to a much lesser extent).

As an example, the ReadiScope documentation explains that, rotational speed on the Tandon 100 is adjusted by turning the trim pot on the small circuit board on the rear of the drive. Turning it clockwise decreases the speed; turning it counterclockwise increases the speed. This will not correct for variations in rotational velocity, but will adjust the average speed in one direction. ReadiScope suggests that if rotational speed fluctuates more than +/− 5 RPM, the spindle drive belt could be faulty, or oil could be on the drive pulleys.

A six-step procedure for aligning the heads on the Tandon 100 is also outlined by ReadiScope. To summarize the operation, clamping set screws are loosened enough to permit careful rotation of the eccentric adjustment screw on the rear of the drive to reposition the heads. This adjustment is carried out while the ReadiScope program is running. When the adjustment produces an acceptable display pattern, the clamping screws are tightened.

Using the DDD, even a misaligned hub can be corrected. ReadiScope outlines this procedure as follows: the hub retaining screws at the rear of the drive are loosened slightly to permit some slight movement of the hub assembly. While running the Alternate Offset test, slight manual adjustments of the position of the hub assembly are made until the display indicates that misalignment has been minimized.

These adjustments should all be made in very small increments and with great care, especially on single-drive machines like PC*jr*, since misalignment problems can be aggravated by misadjustment to such an extent that the drive would no longer function. On a single-drive machine, this would prevent further adjustment of the drive—not to mention use of the machine!

For most users, these five diagnostic programs serve the main purpose—to be able to know or have a good indication *in advance* that a drive requires servicing by a qualified technician. Both ReadiScope and Memory Minder will be of great value to a computer repair shop or a drive technician.

It is unfortunate that none of the programs offers a definitive statement of what constitutes acceptable limits for diskette drive performance parameters. Dysan's Interrogator comes the closest with its default pass/fail values, but even these are prefaced with the statement, "It may be quite sufficient to use the default values set up by Dysan. The default pass/fail limits found in the Interrogator package represent the values we have found to work well with the machines we have tested."

Each of the programs has important advantages, yet each has some major limitations for some users: A disk drive repair technician would prefer the combined numeric and pass/fail output of the Dysan Interrogator. The detailed output offered by Memory Minder makes it a good second choice for the drive technician. The casual user might prefer the ease of operation permitted by Dymek's RID. A user who enjoys lively graphics displays will probably choose Verbatim's Datalife.

The most attractive choice overall, however, is ReadiScope by RSI. Among the features that contribute to this package are its capacity to present its data graphically and numerically, the ability

to output to a printer on either a parallel or a serial printer using PrtSc, and the fact that it can be altered to operate in color. In addition, ReadiScope's manual offers the most thorough treatment of the subject, by far; it can run under all versions of DOS released to date; and its use is not restricted by license to a single computer.

Its main program can be copied onto the hard disks of a number of XT computers in a fixed operation, allowing them all to be tested with a common DDD diskette, thus assuring compatibility of read/write operation. Only the DDD diskette would have to be transported from machine to machine; the operating program would remain resident on the hard disk. In addition, it is the only program that can test both an XT and a PCjr. It would therefore be able to prevent the type of problem encountered by the first unfortunate user described in this article. That is especially important to me: I am that user.

Recording Interchange Diagnostic: $34.95
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1851 Zanker Road
San Jose, CA 95112
408/947-8700
CIRCLE 496 ON READER SERVICE CARD

Datalife Disk Drive Analyzer: $39.95
Verbatim Corporation
323 Soquel Way
Sunnyvale, CA 94086
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Interrogator: $139.00
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Sunnyvale, CA 94089
408/734-1624
CIRCLE 494 ON READER SERVICE CARD

Memory Minder: $99.00
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15100A Central Avenue SE
Albuquerque, NM 87123
505/292-4182
CIRCLE 493 ON READER SERVICE CARD

ReadiScope: $295.00
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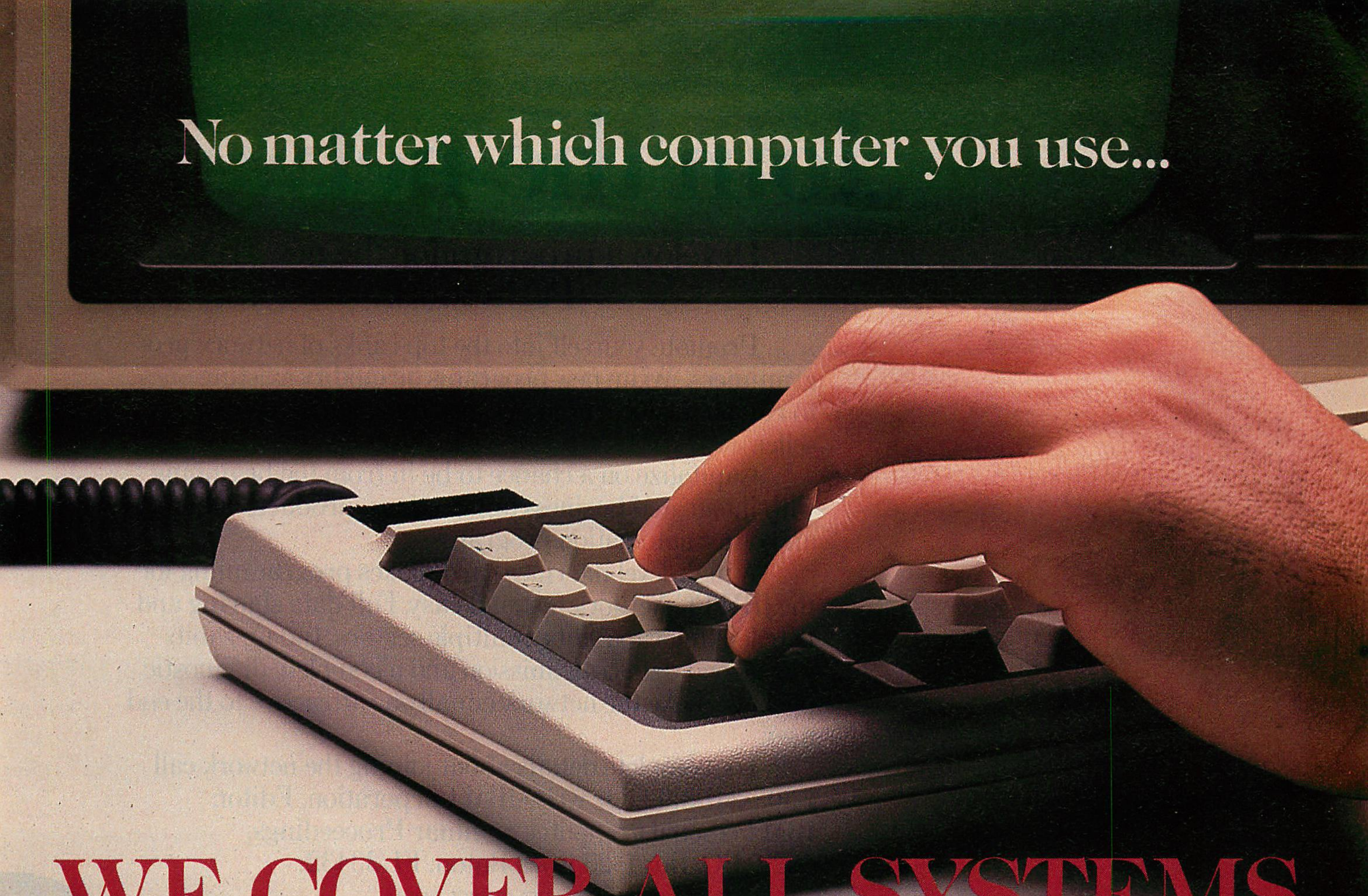
CIRCLE 492 ON READER SERVICE CARD

James Chumbley is manager of quality assurance for Fairchild Semiconductor's linear high reliability products division. He holds a degree in mechanical engineering and owns Colorware, his own software company.



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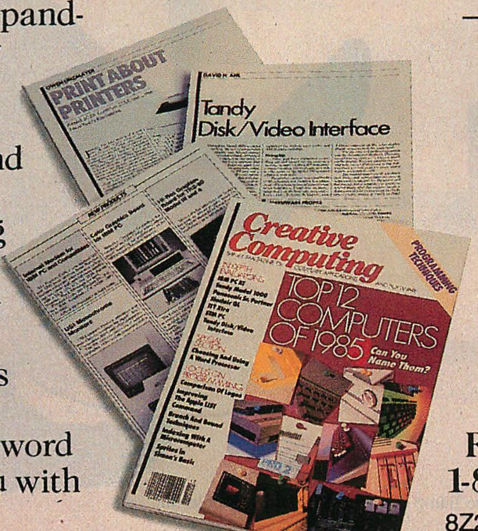

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- 16K RAM
- 8K NET BIOS ROM

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- RECEIVE 219 MHz (CH J)
- SUPPORTS 1000 NODES
- MAXIMUM DISTANCE 5KM RADIUS FROM HEADEND
- MULTIPLE SERVICES POSSIBLE

DIAGNOSTICS
- POWER-ON SELF-TEST
- ON-LINE MEDIA MONITORING

OTHER
- SUPPORTS DMA DATA TRANSFERS
- 2-MEGABIT/SECOND DATA RATE
- MID-SPLIT BROADBAND

FIRMWARE HIGHLIGHTS

OPEN ARCHITECTURE
- PEER-TO-PEER NETWORK
- OPERATING SYSTEM INDEPENDENT
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- CABLE AVAILABLE IN 4 LENGTHS: 25 FT., 50 FT., 100 FT., AND 200 FT.

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• 8 SHORT-DISTANCE KITS	200 FEET	72
• 8 MEDIUM-DISTANCE KITS	600 FEET	72
• 8 LONG-DISTANCE KITS	1,000 FEET	72
• 8-KIT COMBINATION	200 to 1,000 FEET	72

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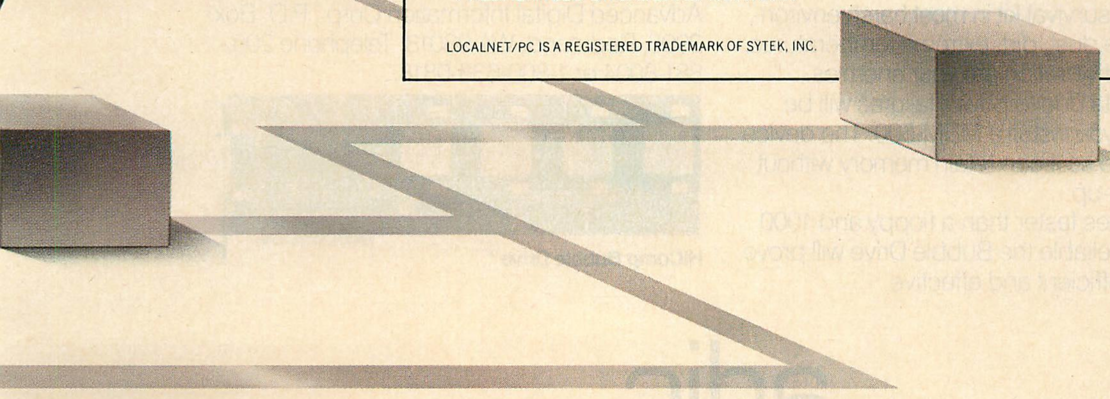

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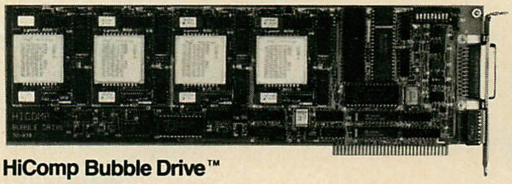

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CIRCLE NO. 248 ON READER SERVICE CARD

Encryption Methods

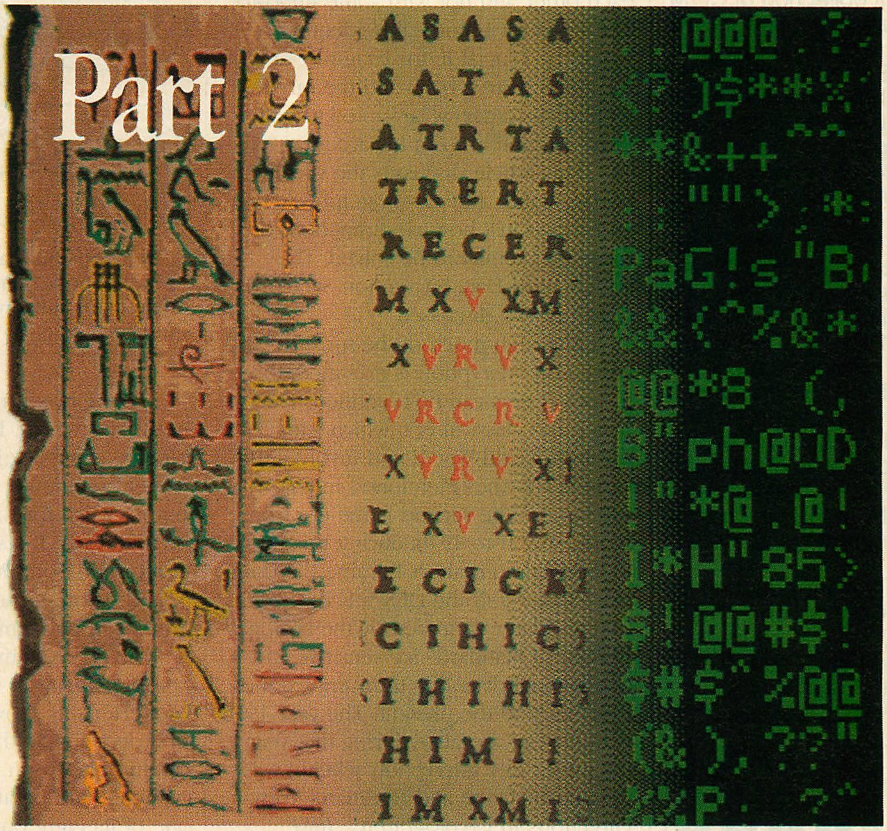


ILLUSTRATION • GARY ZAMCHICK / LEXICA

Public Key Cryptography and the Data Encryption Standard provide effective methods to send secure communications.

VICTOR MANSFIELD

This is part two of a series of articles on encryption. The first part, which appeared in the April issue (p. 96), discussed the fundamental theory of encryption. A future article will review commercial encryption/decryption systems that are available for the IBM PC.

How can secure and unforgeable communication be established between two microcomputer users? Assume that these two users do not trust each other, that their computers are connected to a national network, and that they have had no previous contact. Assume further that both users want to meet security requirements by encrypting their messages.

Two important problems must be solved. First, how should the users exchange keys for the encryption? They cannot simply send them unencrypted over the network, because they know that intruders have access to everything that passes between them. It is possible to send keys by trusted courier, but for

networks with a large number of users, such as those used by banks and the military, this is impractical; too many keys must be exchanged too often. It would be most convenient to use the network for key distribution, but this must be done securely.

The second problem is being sure that they are really communicating with each other and not with some impostor. The need for unforgeable identity would be crucial if, for example, one of the users were a bank and the other were a customer who wanted to withdraw $1 million from his account.

This article discusses the revolutionary Public Key Cryptography system and shows just how elegantly both of these problems can be solved. The widely used Data Encryption Standard (DES) is also discussed.

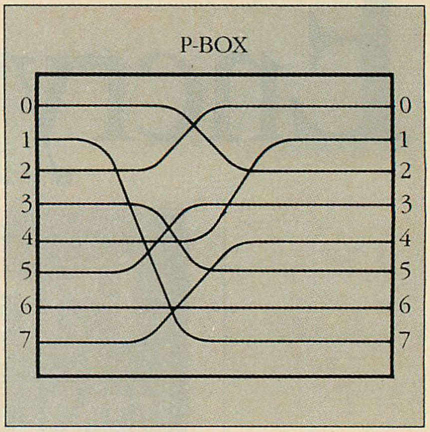
Although much of the sensitive research on encryption is classified, three historical eras can be identified. The first is the classical era, which runs through World War II and involves the various schemes mentioned in part 1 of this series. The second is the era from World War II to 1976; during this period, digital computers became the dominant factor and the DES was devised by IBM and later approved by the National Bureau of Standards for sensitive and commercial data. The third era extends from 1976 to the present. The year 1976 is important, because during that year the public key encryption scheme was devised by Diffie and Hellman ("New Directions in Cryptography," *IEEE Trans. Inform. Theory IT-22,* November 1976, pp. 644-54).

DATA ENCRYPTION STANDARD

IBM developed the DES between 1973 and 1976. This algorithm was approved in 1977 by the National Bureau of Standards for commercial and sensitive data. The approval was initially surrounded by some controversy about just how secure the DES actually is. Military and diplomatic data are handled by systems that are more secure than the DES.

Part 1 of this series explained that modern encryption is fundamentally a series of transposition (or permutations) and substitutions of the plaintext, or unencrypted text. The DES was designed to be conveniently performed in hardware, enhancing the speed and security of the encryption. To that end it is built around the P-box (for permutations) and the S-boxes (for substitutions). A simple P-box shows how a permutation can be done in hardware. Figure 1 is a schematic diagram for the wiring of a P-box.

FIGURE 1: *Wiring a P-box*



The DES is built around the P-box (for permutations), shown here, and the S-box (for substitutions) that is shown in figure 2.

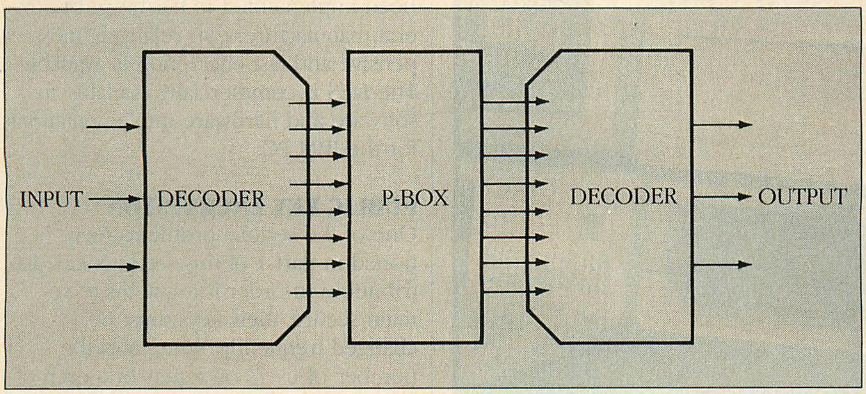
The P-box's input and output are both 8-bit words. If the input word's bits are designated 01234567 from top to bottom, the bit numbering on the output word for the wiring shown must be 27051364. If a signal enters the illustrated P-box on bit 3, it will exit on bit 5, and so on. If the wiring is changed, a P-box can perform any transposition.

An S-box is made from a P-box in combination with two binary-to-decimal converters, as shown in figure 2. The first decoder on the input side converts a value placed on its 3-bit input lines (which could be an octal number) into one of its eight output lines by setting that particular line to 1 and all of the other lines to 0. The P-box permutes the single bit, and the output decoder converts that one-of-eight value to a 3-bit binary number. In this way, one 3-bit word is transformed into another.

If this process seems too magical, an example may help. Use the P-box wiring shown in figure 1 in the S-box shown in figure 2. If the octal numbers 0, 1, 2, 3, 4, 5, 6, and 7 were input sequentially to the S-box, the output would be 2, 7, 0, 5, 1, 3, 6, and 4. If the P-box shown in figure 1 were rotated so that the input and output sides were interchanged and then used in figure 2, the same sequential octal numbers would become 2, 4, 0, 5, 7, 3, 6, and 1.

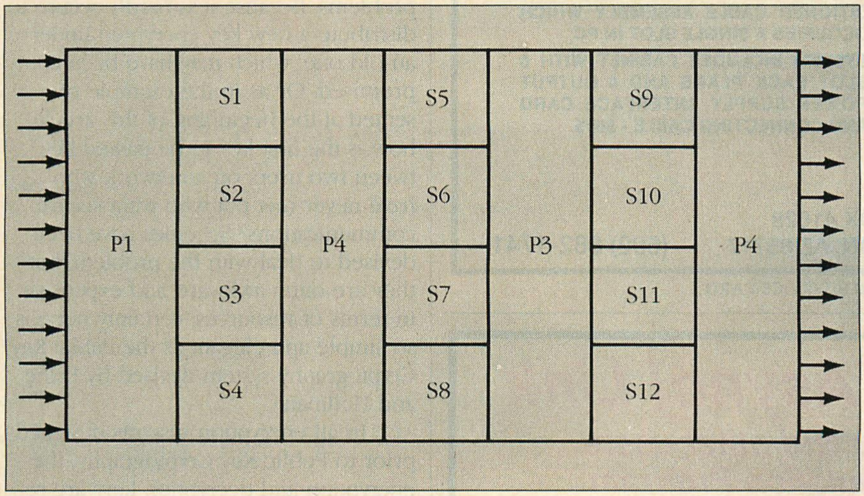
With appropriate wiring, any substitution may be performed in hardware. In the DES, these P- and S-boxes are combined to form product ciphers, as shown in figure 3. In this product cipher, 12 input lines are first permuted in P1. The output of P1 is broken up into four groups of 3 bits each. Each group is then subjected to four inde-

FIGURE 2: *Wiring an S-box*



A substitution, or S-box, is made from a P-box in combination with two binary-to-decimal converters that translate a 3-bit binary code into a one-of-eight code.

FIGURE 3: *DES Product Cipher*



In this product cipher, 12 input lines are first permuted in P1. The output of P1 is then broken up into four groups consisting of 3 bits each.

pendent substitutions in S1, S2, S3, and S4, as described in figure 2. The process is repeated in the following stages.

The DES takes a 64-bit block of plaintext and converts it into 64 bits of ciphertext, using a 56-bit key. A series of 18 different stages is used to do this; these stages employ product ciphers made of P- and S-boxes, like that shown in figure 3. Figure 4 shows an outline of the process. The first stage is a key-independent permutation of the 64-bit plaintext. The last stage is the inverse of the first stage. In between are 16 functionally identical stages designated by i where $i = 1, 2, 3. . . 16$. At each stage a unique subkey, $K(i)$, is generated from the original key, K.

As figure 4 shows, each of the 16 stages involves a permutation: the right 32 bits of input become the left 32 bits of output. At each stage i the right 32 bits of input are also encrypted using a function g with $K(i)$. This encrypted 32 bits is then combined by an exclusive OR with the left 32 bits of input and written as the right 32 bits of output. This function $g(K(i), R(i))$ is where all the complication lies and is composed of a series of key-dependent P- and S-boxes, each of which is unique for each stage i. It is so designed to insure the nonlinearity of the encryption process. For the purposes of this article, it is not necessary to describe g in detail nor explain how the subkeys are generated. Interested readers should consult the National Bureau of Standards publication "Federal Information Processing Standards" (Publication 46), which gives the full specifications.

The DES is designed so that decryption is the reverse of encryption. Although the details of the actual steps are quite complicated, the process is actually just a 64-bit key-dependent substitution cipher, because each 64 bits of input are output as 64 bits of ciphertext.

DATA SECURITY

Since its adoption in 1977 by the National Bureau of Standards, the DES has been implemented in hardware by several manufacturers, so relatively inexpensive and fast encryption is available. The DES is commercially available in software and hardware implementations for the IBM PC.

PUBLIC KEY ENCRYPTION
One of the serious problems mentioned in part 1 of this series is key distribution. In order for systems to remain secure, their keys must be changed frequently. When N is the number of users on a network, each of whom desires secure communications with the N-1 other users, the number of pairs of keys that have to be securely distributed is determined by $N(N\text{-}1)/2$.

Even modest values of N present problems, because it is hardly secure to distribute a new key encrypted under an old one, which may have been compromised. Or as in the example presented at the beginning of this article: how is the first key to be passed between two users on a network who have never met but who want secure communications? Schemes have been devised to deal with the problem, but they are often awkward and expensive in terms of resources; certainly none is so simple and elegant as the Public Key Cryptography system devised by Diffie and Hellman.

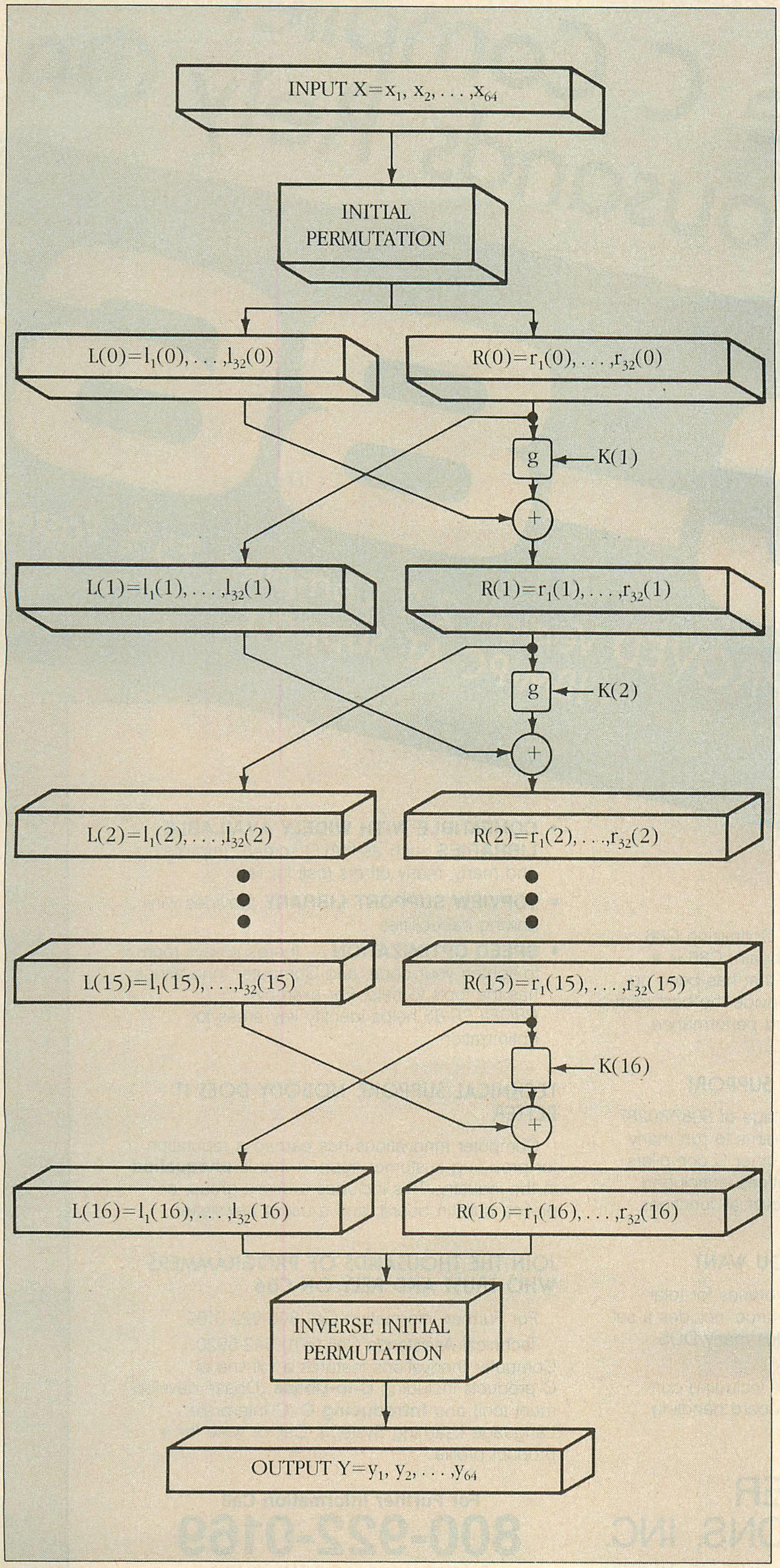
In all encryption systems designed prior to Public Key Cryptography, the encryption and decryption keys are related in some simple way, and both are kept secret. Often decryption is just the reverse of encryption, as is the case in the DES. Diffie and Hellman revolutionized all this by designing a system with two keys: one publicly known encryption key, E, which is published in a directory much like a phone book, and one secret decryption key, D, known only by an individual. In addition, the secret decryption key could be obtained from the public encryption key only with extreme difficulty.

The system is similar to a special mailing envelope that can be filled and sealed by anyone, but that can be opened only by the person whose address appears on it. With this special envelope it is not necessary to worry about the honesty of the letter carrier.

The properties required of the Public Key Cryptography system are explained below. Here, P is the plaintext and C is the ciphertext.

1. $C = E(P)$. This equation says that ciphertext results from encrypting plaintext under the encryption key.

FIGURE 4: *Converting Plaintext into Ciphertext*



The first stage in this process is a key-independent permutation of the 64-bit plaintext. The last stage is the inverse of the first stage.

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2. $P = D(C) = D(E(P))$. This means that plaintext results from decrypting ciphertext with the decryption key.
3. It is exceedingly difficult to find D when E is known.
4. E cannot be broken by an attack in which the intruder can choose the data to be encrypted.

Because of properties 3 and 4, E can be made public. All encryption and decryption keys are generated locally by individuals. The encryption keys are sent to the public directory, in which they can be read by anyone, because they are unencrypted. The decryption key is kept secret by its owner.

Secure communications between two users, Y and M, can be set up in the following manner: first, encryption keys E_Y and E_M are published in a public directory; second, user Y looks up the encryption key for user M in the directory and applies it to the plaintext, P, to get $C = E_M(P)$, which he then sends to user M. User M can decrypt the message by applying user Y's secret decryption key to find that $D_M(E_M(P)) = P$. Because no one else knows user M's secret decryption key and because of properties 3 and 4, it is not possible for an intruder to decipher the message.

Thus, the public key encryption system allows strangers to set up secure communications simply and efficiently, without having to solve the problem of secure distribution of secret keys. Compared to other, more difficult schemes that have been devised to accomplish this task, Public Key Cryptography is beautifully simple and direct.

The next challenge is to find algorithms that obey the above criteria. One developed by Rivest, Shamir, and Adleman ("A Method for Obtaining Digital Signatures and Public Key Crypto System," *Commun. ACM*, February 1978) seems quite secure and has been implemented on the IBM PC. Their method is based on principles of number theory. The method is outlined below:

1. Choose two large prime numbers, Q and P, each in excess of 10^{100}.
2. Compute $N = P*Q$ and $Z = (P - 1) * (Q - 1)$.
3. Choose a number that is relatively prime to Z (having no common factors) and call it d.
4. Find e so that $e*d = 1 \bmod Z$.
5. Divide the plaintext P into blocks, B (considered bit strings), so that when each block is transformed into its numerical equivalent ($a = 1$, $b = 2$, etc.) it falls in the interval $0 <= B <= N$.
6. To encrypt a message, break it into blocks and compute $C = P^e \pmod N$.
7. In order to decrypt C, compute $P = C^d \pmod N$.

To encrypt a message, N and e are needed; to decrypt a message, N and d are needed. Therefore, the public key consists of the unique pair (N, e), and the secret key is d, assuming that N is known. The public key directory contains the user's name, network address, N, and e; d is known only to that user. The example below will clarify the actual application of this algorithm.

The security of the public key encryption method hinges on the difficulty of factoring large numbers—if the cryptanalyst could factor the public N, he could then find P and Q and, hence, Z. Knowing Z and e, it is easy to find d using a famous algorithm of Euclid (for determining the greatest common divisor of two integers and, hence, whether two intergers are relatively prime). Fortunately for the Rivest/Shamir/Adelman method, factoring large numbers is an exceedingly difficult problem that can consume vast amounts of computer time. According to Rivest, Shamir, and Adleman, factoring a 200-digit number

requires about 4 billion years of computer time using the best known algorithm and a computer that has an instruction time of 10^{-6} seconds.

Although some recent improvements in the methods for factoring large numbers have been made by Simmons and others at the Scandia National Laboratories, the algorithm still seems quite secure. On the other hand, there are some reasonable but unproven assertions in the analysis of the factoring problems, so no complete mathematical proof exists that the algorithm is truly secure. For example, there is no absolute guarantee that some clever person cannot devise an extremely efficient algorithm that would allow large prime numbers to be factored on the IBM PC in, say, 15 minutes. Such an exceedingly unlikely event would then make the system completely vulnerable.

The following simplified application of the Rivest/Shamir/Adleman encryption algorithm will help illustrate exactly how it works. Following the steps given above, choose $Q = 3$ and $P = 11$ (these numbers are considerably smaller than the recommended 10^{100}), which produce $N = 33$ and $Z = 20$. Several choices exist for d, but for simlicity choose $d = 3$, because d will then have no common factor with Z, which is 20. (In this simple case, several other odd numbers smaller than 20 could just as easily have been used.) Next it is necessary to find e so that $e * 3 = 1 \bmod 20$; therefore, $e = 7$.

These values of e, d, and N can be used to encrypt the message *bad*; the numerical value 1 is assigned to *a*, 2 to *b*, etc. Making $N = 33$ and restricting the plaintext blocks to single letters from the 26-letter alphabet will satisfy the requirement that the block size be less than N. Table 1 shows the encryption process, and table 2 shows the decryption process.

As this example shows, the Rivest/Shamir/Adleman algorithm works like magic. The computations in this unrealistically simple example are trivial, but in more realistic ones, the computations involved in taking large exponents of large integers modulo for a very large number—for example, $C^d \pmod N$—are demanding. They require full-precision integer arithmetic for integers up to N, which is at least 10^{100}. For this reason, the Rivest/Shamir/Adleman implementation is computationally demanding for machines such as the PC.

One elegant application of Public Key Cryptography involves its ability to provide digital signatures. In the world of paper documents, a unique signature

TABLE 1: *RSA Encryption Process*

P LETTER	P NUMERIC VALUE	P^7	P^7 (mod 33)
b	2	128	29
a	1	1	1
d	4	16,384	16

For the example shown here, N was set equal to 33 and the plaintext blocks were restricted to single letters from the 26-letter alphabet.

TABLE 2: *RSA Decryption Process*

C NUMERIC VALUE	C^3	C^3 (mod 33)	SYMBOL
29	24,389	2	b
1	1	1	a
16	4,069	4	d

The computations involved in this process can be demanding. They require full-precision integer arithmetic for integers up to N, which is at least 10^{100}.

is often the most important mark on the paper, whether the document is a bank check or the U.S. Declaration of Independence. How can an unforgeable and unique electronic identification be obtained for anyone when the possibility of wiretaps and various other forms of attack is everpresent? When a client tells his stockbroker to buy 1 million shares of stock, how can his stockbroker be sure it is really his client giving the order? If one more property is imposed on the encryption and decryption algorithms, this demand can be satisfied.

In addition to the usual property that $D(E(P)) = P$, the stockbroker (or any other user wanting to be sure that the person communicating with him is who he claims to be) should demand that $E(D(P)) = P$. In other words, in addition to the requirement that text encrypted with the encryption key E be decrypted to plaintext with the decryption key D, the stockbroker should require that text encrypted with the decryption key D be decrypted to plaintext with the encryption key E. When either key acts as an encryption key, the other must act as a decryption key.

Digital signatures are provided in the following way. First, the client uses his secret decryption key to encrypt the plaintext message, P. This produces $D_M(P)$. Then the client finds the stockbroker's encryption key E_Y in the public directory and applies it to the result to obtain $E_Y(D_M(P))$, which he then sends to the stockbroker. Upon receiving the client's message, the stockbroker applies his secret decryption key to obtain $D_Y(E_Y(D_M(P))) = D_M(P)$, which he then stores in a safe place. Finally, he looks up the client's public encryption key and applies it to obtain $E_M(D_M(P)) = P$. If this plaintext message makes sense, it must have come from the client, because only that client knows the D_M that was used for the first encryption.

Now suppose the client denies having ordered the 1 million shares, perhaps because a better investment suddenly came up. The stockbroker can then go to the judge with his copy of the client's message encrypted under his secret key, $D_M(P)$, and the client's message, P. The judge then looks up the client's public key and applies it to $D_M(P)$. He finds $E_M(D_M(P)) = P$, which is identical to the copy of P the stockbroker claimed the client sent; obviously, the client did, in fact, tell the stockbroker to buy the shares.

While they carry the client off to jail he might cry over his shoulder that his private key was stolen and that in fact someone else must have sent the purchase request. Society might rightfully require that theft or suspected compromise of a digital signature be reported immediately in order to avoid responsibility for legal obligations sealed with the signature.

Despite that possible problem, Public Key Cryptography offers a simple and elegant method of providing digital signatures. Other ways to obtain digital signatures are possible with conventional cryptography, but none is so direct as the public key method.

CRYPTOGRAPHIC STRENGTH

How secure is the DES or the Rivest/Shamir/Adleman implementation of Public Key Cryptography? What attacks can be mounted against them? Only the impractical one-time-pad encryption sys-

tem can be mathematically proven to be secure; it is secure only because all possible plaintext messages are equally likely for a given ciphertext.

Considerable analysis has been done regarding these two schemes, especially the DES, and although controversy has surrounded the security of the DES, no glaring weaknesses are known for either scheme.

Two general kinds of cryptanalytic attacks can be mounted in order to find the key to a given cipher: analytic and exhaustive attacks. In an analytic attack it is assumed that the algorithm for encryption is publicly known and that only the key is kept secret. An analytic attack derives a set of mathematical equations that expresses the relationship between the plaintext, ciphertext, and key and then solves for the key. Various statistical properties of the language—such as the frequency of individual letters, digrams, trigrams, as mentioned in part one of this series—may also be used to aid in the solution for the key.

The DES thwarts an analytic attack by making the ciphertext such a complicated nonlinear function of the plaintext and key that solving the equations that express their relationship is effectively impossible. The Rivest/Shamir/Adleman algorithm thwarts this type of attack by forcing it to factor very large numbers, an exceedingly arduous job. Recent estimates for factoring large numbers indicate that the computing time required for factoring a 100-digit number, N, on an IBM 370/158 is 8,200 years (Gerver, "Factoring Large Numbers with a Quadratic Sieve," *Math. Comp. 41,* 1983). The factoring time can be greatly increased by increasing N. Because no shortcut methods have been found for factoring large numbers, these estimates are reliable. However, no complete mathematical proof exists that such shortcut methods do not exist; thus, some small doubt remains.

In an exhaustive attack, a particular plaintext with its corresponding ciphertext is known along with the encryption algorithm. Each possible key is used to encrypt that particular plaintext. The resulting ciphertext is then compared to the original ciphertext to see if a match is found, which would indicate that the correct key has been used. This attack may be thwarted by using long keys that give rise to a very large key space. So many keys would have to be tried that the exhaustive search would prove to be impractical.

The Rivest/Shamir/Adleman algorithm uses a key space that is so large

for the size of the numbers suggested that exhaustive searches are effectively ruled out. On the other hand, one of the chief criticisms of the DES is that its relatively small 56-bit key means that there are only $2^{56} = 7.026E16$ possible keys. It has been estimated that by about 1990 a computer could be built for several tens of millions of dollars that could find one 56-bit key per day (Meyer and Matyas, *Cryptography: A New Dimension in Computer Data Security,* 1982). Considering the importance of the data encrypted under the DES, the cost of such a computer is not considered too high.

It is possible, however, to improve the cryptographic strength of the DES by using multiple encryptions with different keys or running it in a stream mode, in which a given block of data depends on the entire encryption history of all previous blocks.

IBM spent 17 years designing and validating the DES and employed several outside consultants. In addition, an independent validation was initiated by the National Bureau of Standards and performed by the foremost cryptographic experts at the National Security Agency (NSA), who approved it for unclassified federal data. Finally, the DES was adopted by the American National Standards Institute (ANSI).

Despite these efforts, controversy has arisen about the DES. Aside from the relatively small key size (which was reduced from the original 128 bits to 56 bits at the request of the NSA for reasons that were not made public), few details are known about the DES. The methods of analysis and the exact design principles used by IBM and the NSA have been classified by the U.S. government. Because this information is not available to a wide spectrum of experts, some claim that IBM's and NSA's statements are unreliable.

Other critics have suggested that an intentional shortcut may have been built into the algorithm to prevent anyone except government officials from easily breaking the code; they claim that this is why the government will not make public the design principles of the S-boxes. This view may seem somewhat paranoid, but in view of possible future developments in the microcomputer revolution, this possibility cannot be lightly dismissed.

For example, consider the possibility that telephones may be connected to microcomputers, which encrypt the data before they go out of the house or office. Then users will be able to send electronic mail or talk with other people and never worry about any intruders having access to their conversations. Many industries (and criminals) would be happy right now to pay handsomely for such a guarantee.

On the other hand, it is obvious that the various federal agencies, such as the FBI, CIA, and NSA, would not like to be denied the possibility of telephone wiretaps and other traditional means of information-gathering. In addition to the clear needs for prevention and prosecution of crime are serious considerations of national security.

These concerns have prompted the question of whether the talent and industry of American scientists should be openly directed toward the development of secure encryption in such a way that any hostile foreign government could easily make use of it. Such concerns have prompted the U.S. government to ask for voluntary censorship on the part of cryptologists—a request met with little enthusiasm because of the long tradition of open exchange of information in the academic world.

Because of the controversy about the DES, the Senate Committee on Intelligence conducted an investigation into the matter and concluded that, in fact, all was well with the DES. This is of limited comfort to DES's critics, because it amounts to the federal government saying, "Trust me." Given that everything in a cryptographer's training compels him to trust no one, this is a difficult request indeed.

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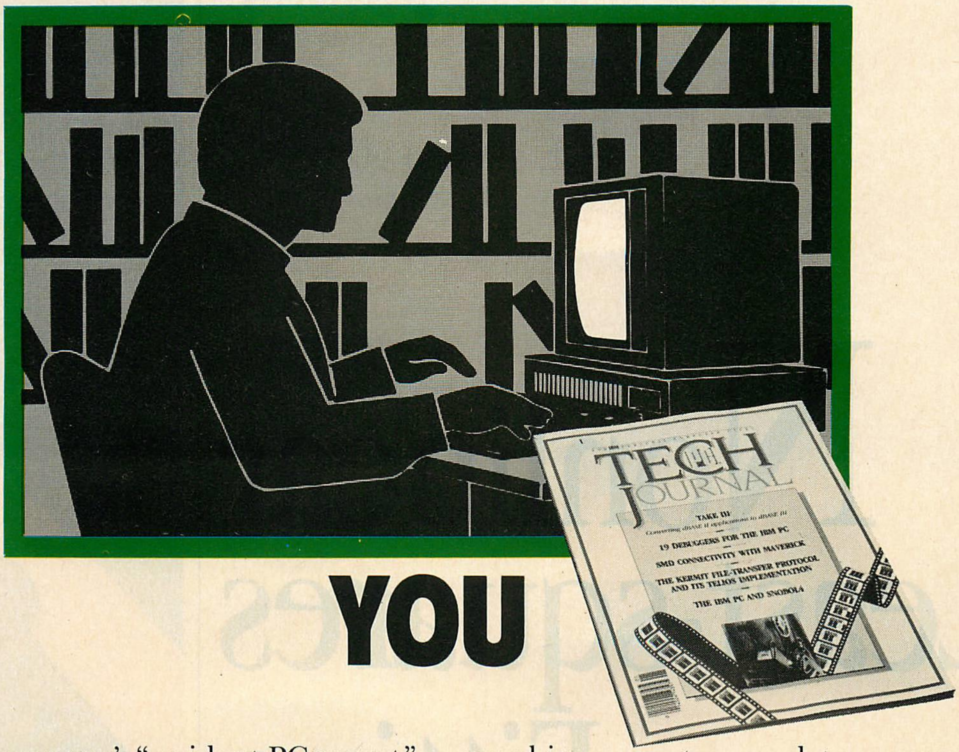

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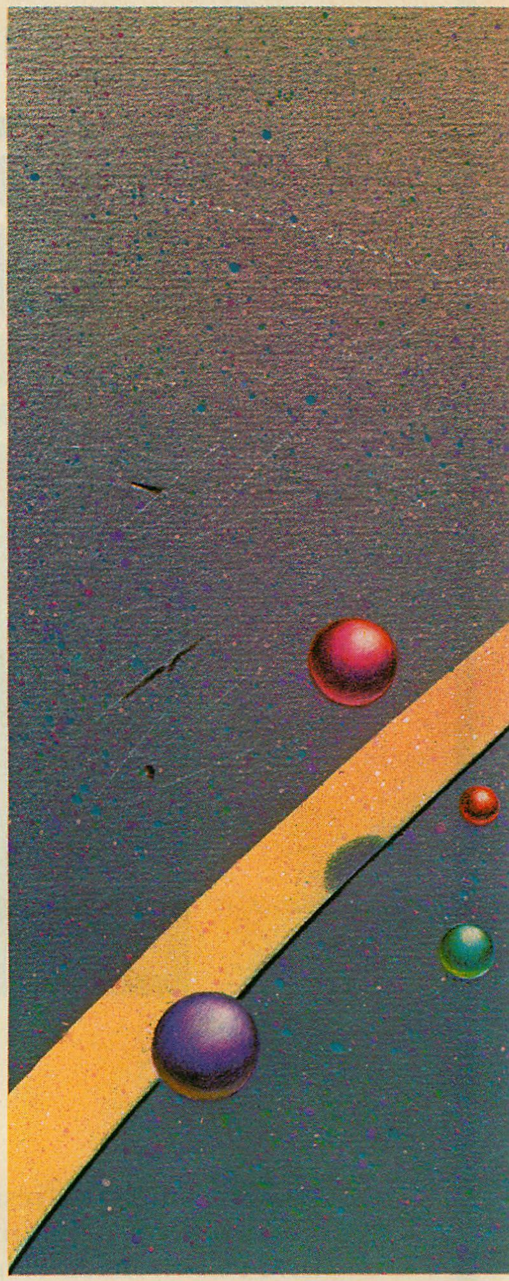


WALTER SCHREINER, MICHAEL KRAMER,
SIMON KRISCHER, and YEDIDYAH LANGSAM

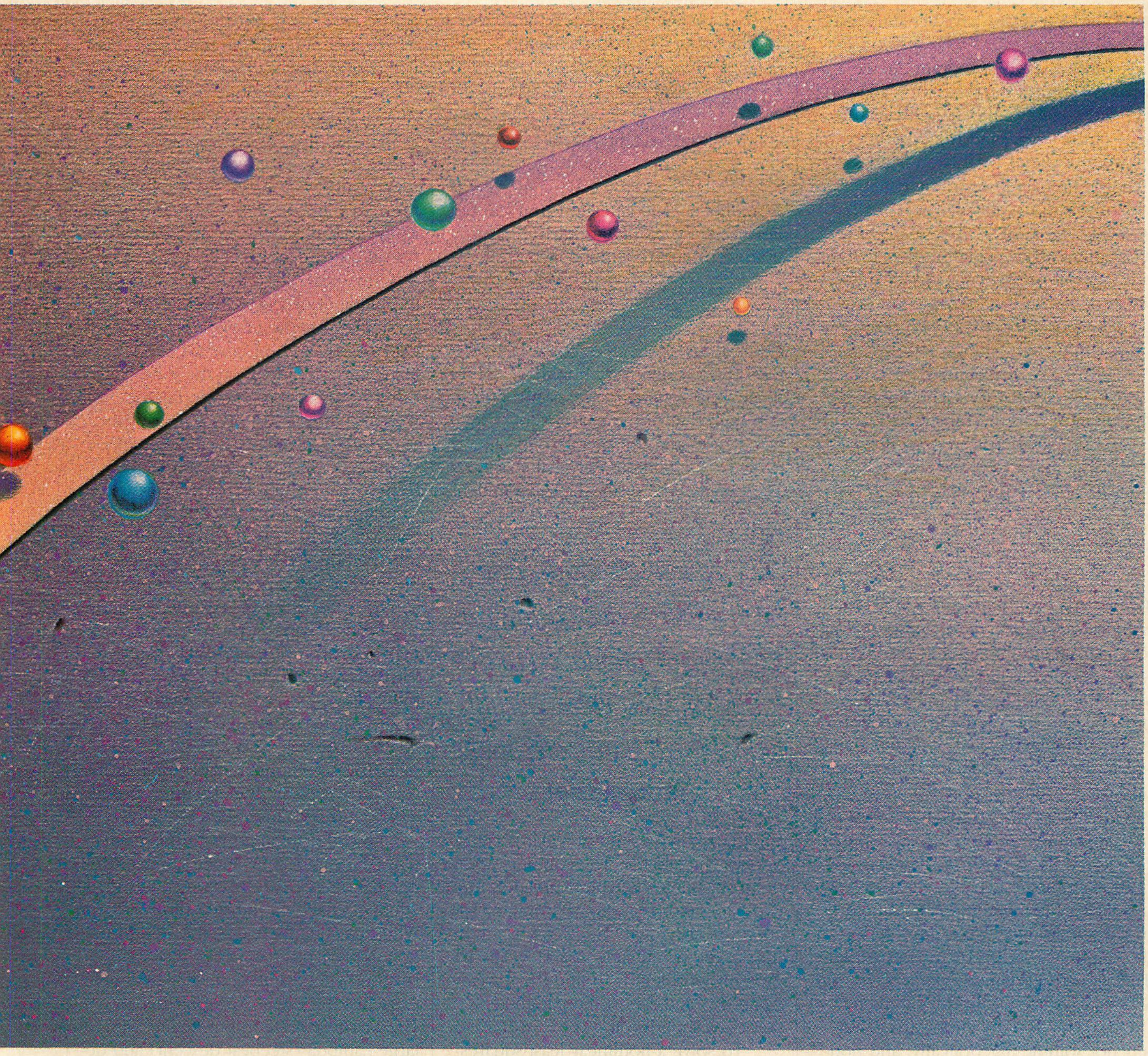
A BASIC program uses the Marquardt algorithm to least-square-fit a set of data points to a curve.

Suppose a player wants to know how long it will take to learn a new computer game to a certain level of proficiency. He records his score each time he plays (table 1) and then plots those scores (figure 1). After a while, enough data exist to draw a smooth curve through the points and extrapolate it. He is not satisfied, however, with a hand-drawn curve; he wants an equation to represent the data.

He picks the exponential function

$$Y = a[1 - exp(-bX)]$$

because the data look as though they might be reaching an asymptote. Y is the score, X is the number of times the game is played, and the constants a and b are parameters to be determined.



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To find values for a and b, the player picks two data points indicative of the trend and evaluates the equation twice. This gives two equations and two unknowns which can then be solved. Unfortunately, none of the other data points that were so painstakingly recorded was used in determining a and b. As a result, the curve goes through the two chosen points exactly, but ignores all the others.

What is really needed in this situation is a least-square fit to all of the points—one that will optimize a and b so that the curve comes as close as possible to every point.

The BASIC program described in this article, MARQFIT.BAS (listing 1), can be used to least-square-fit any function, linear or nonlinear, to a set of data points. The user supplies the program with the data to be fitted, a suggested function with adjustable parameters, and a set of initial values for these parameters. The program will calculate the best value for these parameters that is consistent with the data and will generate a statistical report of how good the fit is. More importantly, the program has built-in sophisticated plotting routines that allow the user to visually compare his data to the fitted function. This program can be easily modified; it also can be compiled.

Table 1 is an example of a relationship between a dependent variable, Y, which represents experimental data, and an independent variable, X. The relationship between the two variables can be formalized by saying that Y is a function of X, which is written as $Y = f(X)$. This relationship may be used to predict what the values of Y will be for values of X that are, as yet, unexplored.

The process of optimizing a function that is representative of experimental data is known as *curve-fitting*. Computer programs are not able to decide which function type should be used to fit the data, but they can indicate the best fit for the particular function being used. The computer finds numerical values for the parameters (for example, a and b in the computer-game example above) that are most consistent with the particular data (the "best fit"). If the program has trouble fitting the data, or

if the fit looks poor, another function should be tried.

How does the program decide what constitutes the best fit? It adjusts the parameters until it minimizes the sum of the squares of the difference between Y values calculated from the function and Y values in the data. For obvious reasons, the method is called least-squares analysis. There are many algorithms for carrying out this analysis, but one that is particularly well-suited for general purpose work is the Marquardt algorithm, which—in most cases—finds the solution rapidly.

If the data points are (X_i,Y_i), where i runs from 1 to N (N is the number of data points), and the function to be fit is $Y = f(X,P)$, where P represents the free parameters, then the sum of squares to be minimized is

$$S = \sum_{i=1}^{N} (Y-Y_i)^2 = \sum_{i=1}^{N} [f(X,P)-Y_i]^2$$

To find the minimum value of S, elementary calculus is used to differentiate S with respect to P, set the result equal to 0, and solve for P. When there are several free parameters, $(P1,P2,\ldots)$, S must be differentiated with respect to each parameter. A set of simultaneous equations is thus obtained. This calculation can get out of hand, even for simple functions, and an exact solution may not be possible in closed form.

When the function is linear in the fitting parameters (that is, there are no products of parameters or parameters in exponents, etc.), an exact solution to the minimization problem is possible. This situation is called *linear regression*. When there are nonlinear parameters in the function, the equations are generally not soluble algebraically, and nonlinear regression results. Of course, a nonlinear regression program can also be used to solve a linear problem, but it will do so less efficiently.

Multilinear regression is an extension of linear regression, except that instead of one independent variable, X, there are several: $X1$, $X2$, etc.

At this point, a common cause of confusion should be mentioned. In dealing with least-squares fitting, it is easy to forget what is varying and what is fixed. When the function is being used to represent the data, X is the independent variable and the parameters, P, are fixed. In the least-squares fitting, however, X and Y are fixed (they are the observed data points, X_i, Y_i) and the parameters, P, are the variables. The terms *linear regression* and *nonlinear regression* refer not to the behavior of the independent variable X, but to the parameters, P. Thus, the function

$$Y = a + \frac{b}{x} + c\ exp(-X)$$

is linear, whereas the function

$$Y = aX^{-b}$$

is nonlinear. The latter function can be linearized by taking the logarithm of both sides and redefining terms:

$$\ln(Y) = \ln(a) - b \ln(X)$$
$$Y' = a' - bX'$$

Because the proficiency curve $Y = a[1-exp(-bX)]$ is definitely nonlinear, a nonlinear least-squares regression routine is required to fit the parameters.

Regression can be pictured as a surface in a multidimensional space. The parameters, P, are the independent variables and the sum of squares is the dependent variable. The contour plot in figure 2 shows the typical situation for a two-parameter regression problem. The contours are equal values of S as a function of the parameters, a and b. The regression problem is to find the lowest value of S and report the parameters that correspond to it.

The typical Marquardt fit begins with S decreasing rapidly while Lambda decreases to the smallest value permitted by local parameter space.

To solve a nonlinear least-squares problem, an iterative technique is required. The sum of squares is evaluated for some initial estimates of the parameters, say at point Q. Next, the surface in "parameter space" in the vicinity of this point is examined to find the local curvature. Based on this information, a new set of parameters, say point R, is determined by computing a change vector, ΔP, which is added to the old estimates. Symbolically,

$$P_R = P_Q + \Delta P$$

The process is done repeatedly until convergence is reached.

To compute ΔP, one of several basic methods is employed. The simplest method is to find the slope at point Q and move in that direction. This is called the *method of steepest descent*. If the surface is not cylindrically symmetric, however, this direction does not necessarily point to the minimum. This is the case shown in figure 2, in which the successive iterations move from Q to R to S, etc., and never point directly to the minimum at C. In spite of this difficulty, the direction of steepest descent is always a good one in which to move, if other more sophisticated algorithms fail to produce a ΔP that will result in a decrease in S.

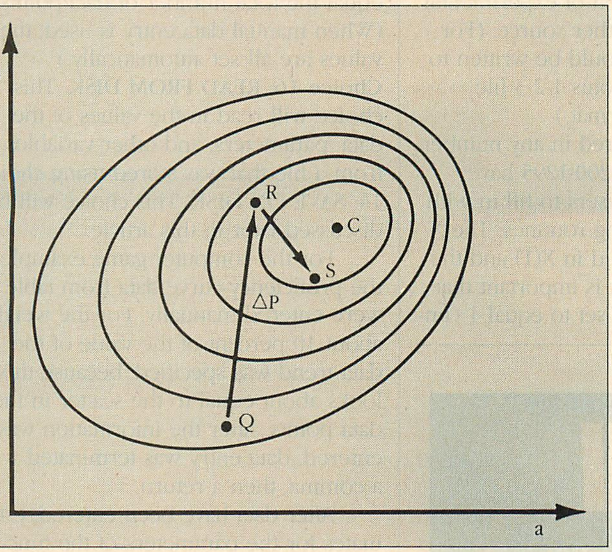
By expanding the expression for the gradient of S in a Taylor series and retaining only the first-order terms, an expression can be found for ΔP that takes into consideration the local curvature. If the chosen function fits the data well, the mixed second partial derivatives can be dropped, giving an expression for ΔP that involves only the first derivatives of the function with respect to the parameters. This is the Gauss-Newton method. Near the minimum, this method gives rapid convergence because of the quadratic nature of the sum of squares in this region.

In the Gauss-Newton method, it is necessary to invert the matrix of data for the independent variables; the possibility always exists that the matrix is singular and, therefore, does not have an inverse. This may result from approximations or computational rounding errors. In any event, the algorithm breaks down, and ΔP cannot be calculated.

In order to circumvent this problem, Marquardt introduced an algorithmic parameter, Lambda, which has the effect of changing the step direction. When Lambda increases, the step direction approaches the steepest descent direction; when Lambda decreases, it approaches the Gauss-Newton direction. The Marquardt algorithm begins with a large Lambda (steepest descent) and decreases it after every iteration. If matrix inversion problems are encountered along the way, Lambda is increased until the matrix can be inverted. In effect, the algorithm takes the most efficient step possible for the current region of parameter space. As the minimum is reached, Lambda approaches 0 and the algorithm converges rapidly with pure Gauss-Newton steps.

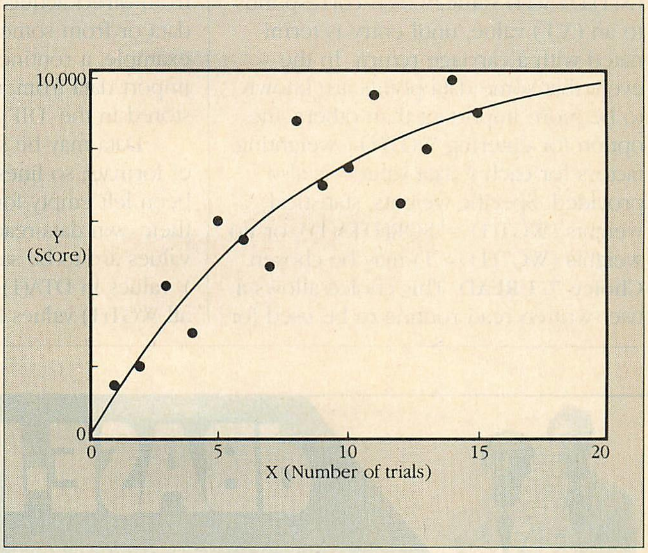
Convergence can be defined in one of several ways. Most commonly, iterations are stopped when the fractional change in S is less than a preset value. Alternatively, the tests may be made on ΔP, which must go to 0 at convergence. Both tests may be necessary when the contour in the region of the minimum is very flat or when the minimum is located along the bottom of a steep-walled, slowly curving valley.

FIGURE 1: *Proficiency Curve*



This curve is the computer-game score, as a function of the number of times it is played. The circles represent data from table 1; the curve is a theoretical fit to the data.

FIGURE 2: *Contour Plot*



This is a contour plot for the sum of squares, *s*, for a regression problem with two free parameters. The problem is to find the lowest value of *S* and the corresponding parameters.

The least-squares convergence problem is easy to visualize in two dimensions, but in three or more it can become nearly impossible. As a result of this, multiparameter fitting can be deceiving. If a relatively flat region of parameter space is encountered, a regression program may appear to have converged, when in fact it may be quite far from the minimum.

Alternatively, the program may converge to a local minimum, while over the next "hill" there is a much better fit. The surface itself also may be sensitive to the errors in the data points, and that surface may change significantly if the data is remeasured. All of these problems are severely compounded if the function that has been chosen does not fit the data well. Care must be exercised, therefore, in using least-squares programs. Knowing how a program behaves under "normal" circumstances is helpful in diagnosing problems.

With the Marquardt algorithm, a typical least-squares fit begins with *S* decreasing rapidly while Lambda decreases to the smallest value that is permitted by local parameter space. After Lambda stabilizes, *S* decreases at a relatively constant rate. When convergence is near, *S* may decrease rapidly to the minimum and Lambda becomes very small. Finally, at convergence, *S* remains constant and Lambda increases rapidly because of singularities introduced by computational rounding.

Any one or more of these "phases" may be missing, depending on the starting point and the complexity of the problem. There is also a possibility that the algorithm simply will not converge. In that case, another function should be chosen for estimation.

RUNNING THE PROGRAM

The menu-driven program (listing 1) has been written for an IBM PC with 128KB of memory, using IBM BASIC running under DOS 2.0. Any monitor may be used for running the fitting part of the program, but a color graphics adapter and graphics monitor are required to make use of the plotting option. The following sections outline the procedure for using MARQFIT.BAS.

Before the Marquardt program can be run, two subroutines must be written: one to evaluate the function $Y = f(X_i,P)$ at each data point, X_i, and the other to evaluate the first derivative of $f(X_i,P)$ with respect to each parameter, P, at each data point. The following equations apply to the computer-game proficiency function discussed above:

$$Y = a[1 - exp(-bX)]$$

$$\frac{\partial Y}{\partial a} = [1 - exp(-bX)] = \frac{Y}{a}$$

$$\frac{\partial Y}{\partial b} = a\,X\,exp(-bX) = X\,(a - Y)$$

If the function is so complicated that the derivatives cannot be evaluated in closed form, they can be evaluated numerically. For example,

$$\frac{\partial Y}{\partial a} \simeq \frac{f(a + 0.5\Delta a) - f(a - 0.5\Delta a)}{\Delta a}$$

If numerical evaluation is used, however, care must be taken to choose Δa so that the difference in the numerator is not less than the precision with which f can be evaluated (usually six or seven digits in single precision); otherwise round-off error will cause the results to be meaningless.

The subroutine to evaluate the function must be coded beginning at line 20000 (see listing 1). All of the parameters used in the function should be assigned to the array PARM(30). Thus, in the function

$$Y = a[1 - exp-(bx)]$$

PARM(1) can be called *a* and PARM(2) can be called *b*. In this routine, *Y* is represented by the variable FUNCTN.

The subroutine to evaluate the derivatives must be coded beginning at line 21000. The derivatives of the functions with respect to each parameter are to be placed in the array DERIV(30) where DERIV(1) contains the derivative of the function with respect to PARM(1), DERIV(2) contains the derivative with respect to PARM(2), and so forth. Once the FUNCTN and DERIV subroutines have been written and included, the fitting program may be run.

The menu provides three choices for entering data: 6, 7, or 16. All data input routines use the string variables T1$ and T2$ as buffers. This allows testing for the null string, which signals the end of data entry. When the program requests input for multiple variables, a comma and a carriage return must be entered to terminate data entry.

Choice 6: MANUAL. This choice allows

each point to be entered manually. The program prompts for the entry of each (X(I),DTA(I)) value, which corresponds to an (X,Y) value, until entry is terminated with a carriage return. In the event that some data points are known to be more important than others, the option for entering WGT(I)—weighting factors for each y data value—is also provided. Specific weights, statistical weights (WGT(I) = SQR(DTA(I)), or no weights (WGT(I) = 1) may be chosen.

Choice 7: UREAD. This choice allows a user-written read routine to be used for data entry. It is intended for users who have data already stored on disk, either from direct acquisition of experimental data or from some other source. (For example, a routine could be written to import data from a Lotus 1-2-3 file stored in the .DIF format.)

Data may be stored in any number of formats, so lines 1200-1295 have been left empty for users to fill in with their own data-reading routines. The X values are to be stored in X(I) and the Y values in DTA(I). It is important that all WGT(I) values be set to equal 1 (unless specific weights are declared). The value of NOBS% should also be set to equal the total number of data points. (When manual data entry is used, these values are all set automatically.)

Choice 16: READ FROM DISK. This choice will read in the values of the data, parameters, and other variables from a file that was stored using choice 14: SAVE ON DISK. This choice will be discussed later in this article.

For the computer-game example, the proficiency-curve data from table 1 were entered manually. For the weights, about 10 percent of the value of the data trend was specified, because this looks about equal to the scatter in the data points. After the information was entered, data entry was terminated with a comma, then a return.

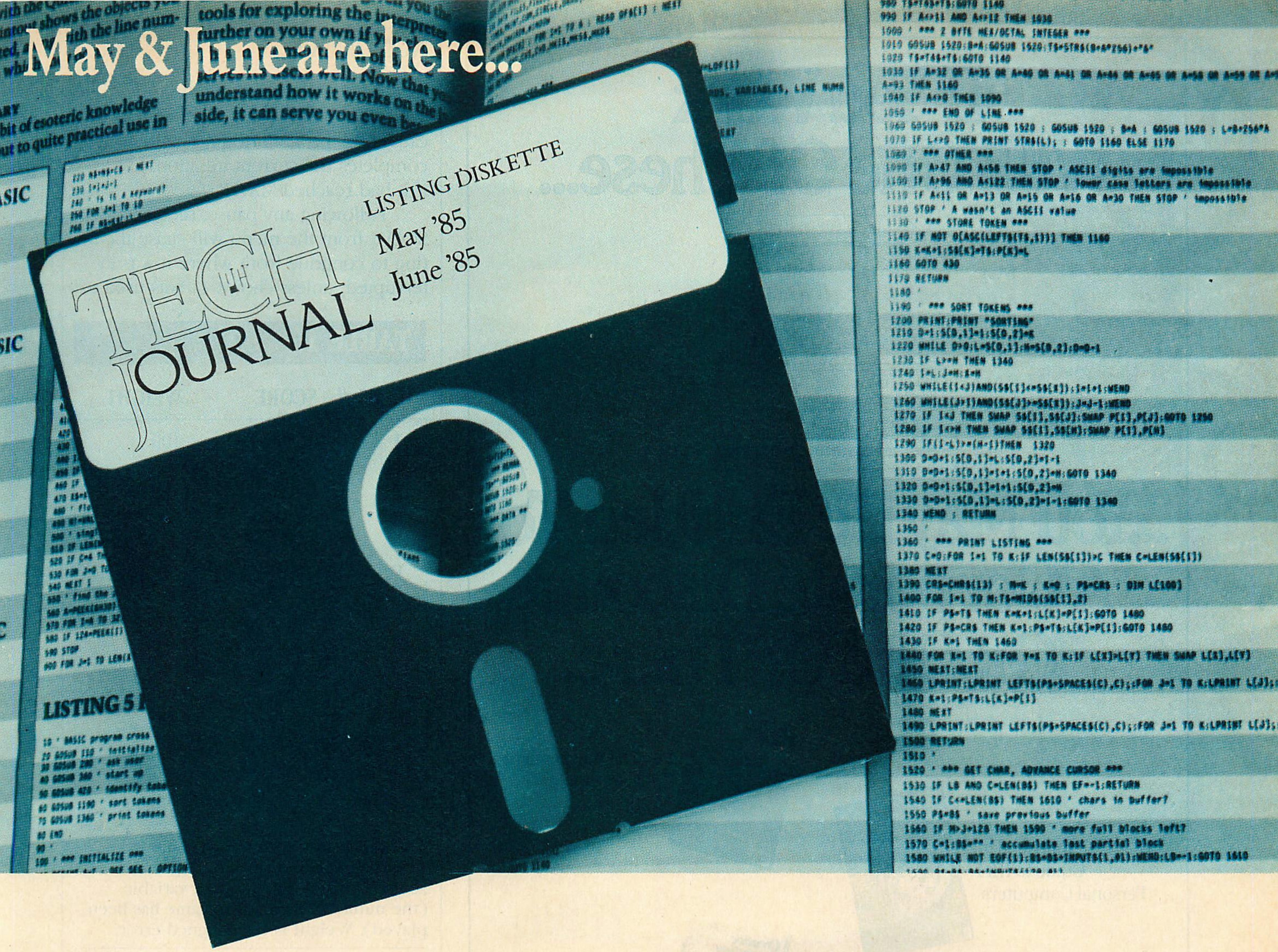
After data have been entered, estimates for the parameters of the function must be provided. This is done with choice 11. The program will then optimize these parameters. Only ballpark values are needed, but the better the estimates, the greater the likelihood of successful and relatively quick convergence. If the program has difficulty (ways to recognize problems will be discussed later), the fit can be interrupted and different starting values for the parameters can be used (more on this later, as well).

Choice 4: PLOT. This choice also can be selected before the fitting routine is run, allowing the user to see how close the initial estimates are. In fact, it is often useful to plot the data even before selecting a function to ensure that an appropriate one is chosen.

In the computer-game problem, the maximum seems to be in the vicinity of 10,000, so a = PARM(1) = 10,000 and b = PARM(2) = 0 were chosen as initial guesses. Choice 11:FIX is used to enter the parameter estimates; it also is used to change parameter values or simply to review the current values without changing them.

When these preliminary steps have been performed, the nonlinear least-squares-fit problem can be solved by selecting choice 3:SOLVE. The program prompts for MXITR, the number of iterations to be performed before pausing. If convergence to a solution occurs prior to MXITR iterations, the program prints out the fitting parameters and their errors, along with some statistical data on the fit and returns to the menu.

If convergence is not reached prior to MXITR iterations, the program pauses and prints out preliminary results to let the user reconsider his data and/or fitting function. The user may also inter-



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rupt the iterations before reaching MXITR by pressing function key F3. This causes the program to pause after it completes the current iteration, just as if it had reached MXITR.

Following any pause, requesting SOLVE from the menu will cause the fitting to continue from where it was interrupted, unless choice 11 was used to

TABLE 1: *Game Scores*

GAME #	SCORE	WEIGHT
1	1,500	100
2	2,000	200
3	4,250	300
4	2,900	400
5	6,000	500
6	5,500	600
7	4,750	700
8	8,750	700
9	7,000	800
10	7,500	800
11	9,500	800
12	6,500	900
13	8,000	900
14	10,250	900
15	9,000	900

This table shows the relationship between a dependent variable (game scores) and an independent variable (the number of times the game has been played). Weight is the assigned error.

change parameters, choice 12 or 13 was used to fix or free parameters, or choice 8, 9, or 10 was used to modify data in some way. (One word of caution, however, about parameter values when the program pauses: a current parameter value P with error ΔP does not imply that the real solution is somewhere in the range P$\pm$ ΔP. As in any iterative process, the parameters are just intermediate values that give the current sum of squares.)

The utility of this program lies not only in its ability to fit data, but also in its ability to provide a plot of those data points with the fitted function superimposed. In fact, the program can be used as a stand-alone data- or function-plotting tool without the fitting features. When the plotting routine is run, another menu of choices is presented:

1. Plot data points and the fitted function
2. Plot residuals (Fit minus measurement)
3. Plot % residuals

Choice 1 produces the normal plot, which shows the raw data (plotted as circles) and the function (plotted as a

continuous line). Choices 2 and 3, on the other hand, allow a deeper look at how good the fit is by plotting just the differences (or percent differences) between the original data and the fit.

Three variations of graph style may be used in plotting data: log axes, linear axes, or a combination of the two. The computer reports the range of the data and allows the user to initialize the plot parameters by choosing a range for the *X* and *Y* axes. The plot is now defined.

If the graph set-up parameters are satisfactory, the plot may be recreated at any time by pressing F4—the "quick-plot" key. This feature is useful for jumping back and forth between fitting and viewing the data.

At the end of each iteration, the program prints the current weighted sum of squares, *S*. By monitoring this, the user can tell whether convergence has been reached. In the computer-game example, *S* decreases rapidly to about 10^{13}. Subsequent decreases in *S* tend to be small until the solution is reached. The convergence criterion requires that the fractional change in all parameters be less than a preset value.

During the last iteration or two, Lambda increases several times while *S* remains constant because parameter space flattens out near the solution. The number of increases in Lambda (INCR) at this stage is printed; this gives a clue to how well determined the solution is. Typically, the better the fit, the more times Lambda increases at convergence.

At convergence the program reports the final values for the two parameters, PARM(1) = 10,975 ± 3 and PARM(2) = 0.119 ± .014. This function,

$$Y = 10{,}975\,(1 - exp(-0.119\,X))$$

is plotted as the solid curve in figure 1, and the fit seems quite reasonable. The errors on the parameters, however, should not be taken too seriously here, because of the somewhat arbitrary way in which errors (that is, weights) were assigned to the data points.

The ratio of the number of sum-of-squares calls (NSSC) to the number of iterations (NITR) measures the average number of times Lambda increased or decreased per iteration. Ratios of about 2 are normal. Higher ratios indicate a difficult parameter space for convergence, but may also appear when convergence is rapid (as in this example). The number of derivative calls (NDC) is also printed, thus providing another indication of how difficult convergence was. The final value of Lambda and the final vaue of the weighted sum of squares are also printed.

TABLE 2: *Main Routines of MARQFIT.BAS*

LINE #	FUNCTION	LINE #	FUNCTION
400–660	Menu	4000–4070	Compute chi-squared
800–820	#1—Title Entry	4500–4750	Choleski backward solution
850–860	#2—Printer toggle	5000–5220	Choleski decomposition
900–1060	#3—Solve	5500–5570	Weighted sum of squares
1300–1370	#4—Quit	5700–5770	Unweighted sum of squares
1400–1690	#5—Manual data entry	6000–7130	Main math routine for fitting
1800–1820	#6—User-written read routine	10000–10470	Function-key-trapping routines
2000–2160	#7—Edit data values	15000–18160	Plotting routines
2200–2300	#8—Scale X, DTA, WGT by a constant	16000–16160	Prepare data for plotting
2400–2440	#9—Zero data and parameters	16300–16440	Calculate plotting function
2500–2780	#10—Enter/review/change parameters	16500–16860	Set up axes, tick marks, and labels
2800–3100	#11, 12—Fix or free a parameter	17000–17150	Plot data and function
3200–3360	#13—List/print data and parameters	19000	Error-trapping routine
3400–3700	#14, 15—Save/read variables to/from disk	20000	User-defined function and derivative routines
		21000	

This table explains the functions of the most important sections of MARQFIT.BAS (listing 1).

Other fitting statistics that are computed are the standard deviation and chi squared. If the fit is good (if it accounts for all of the systematic variations in the data and only statistical fluctuations remain), the ratio of chi squared to the number of degrees of freedom (χ^2/DF) should be about 1. If it is not, either the model does not account for significant trends in the data or the assigned weights are incorrect.

Errors (that is, weights) should not be asigned to data points arbitrarily. These errors are usually dictated by a knowledge of the various sources of measurement errors, such as counting errors. When these errors are used in the least-squares fit, the value of χ^2/DF acts as a check on the correctness of the measurement errors. In the computer-game example, information about the expected error, other than the scatter in the data points, was not available. Hence, the value of χ^2/DF$\simeq$ 4 that was obtained is not unreasonable.

Proper assignment of errors on the data points is important for several reasons. First, unreasonable values can result in significantly different fitted values. For example, assigning WGT = 100 to the first seven data points and WGT = 1,000 to the rest would result in PARM(1) = 9,280 and PARM(2) = 0.205, with χ^2/DF = 102. On the other hand, an equal weight assignment of 1,000 to all points gives PARM(1) = 10,910 and PARM(2) = 0.123 with χ^2/DF = 1.5. Results are usually fairly independent of weights, if the weights are reasonable.

Second, with correctly assigned errors, a poor χ^2/DF indicates an incomplete fit of the data trends. For example, if the data in table 1 were fit to a straight line going through the origin, ($Y = mX + b$, with b fixed at 0), a slope of 700 and χ^2/DF = 18 would be obtained. Inspection of that fit will confirm the results and, at the same time, reveal the cause: the line goes under most of the data points in the middle.

If the program does not seem to converge, there are several possible causes. First, check the derivative calculations for correctness. That is the most likely place for an outright bug. Next, is the function coded properly? If no problems are found, consider whether the function really describes the data being fitted. If it doesn't, there are likely to be large error limits on the fitted parameter values (often larger than the absolute values of the parameters themselves). This causes convergence to be reached very slowly.

Another possible cause for poorly fitted parameters is that too many parameters were used to characterize the trends in the data. Each parameter should be carefully chosen to represent a specific and unique trend in the data. Poorly fitting parameters and slow convergence result if the data are not able to distinguish all of the variations that the parameters were supposed to represent. In this case, a fit that is nearly as good can usually be obtained by eliminating or fixing the poor parameters: convergence will be reached faster.

If everything is found to be correct and the problem is difficult to solve because of strongly coupled parameters, the user may possibly induce convergence by fixing several less important parameters (using menu choice 12) for a while, allowing the remaining parameters to converge. Next, free the fixed parameters (using menu choice 13) one or two at a time, fitting to convergence each time, until all are freed.

When difficulty is encountered in reaching convergence, the stability of the final solution should be tested. This can be done by restarting the problem with a different set of initial parameter estimates. If the same final results are not obtained, within approximately the error limits of each parameter, several local minima may be in the area.

BELLS AND WHISTLES

The program has several other features:

Choice 1: ENTER TITLE. This option is used to document output and data files saved on disk. The title may be up to 70 characters in length.

Choice 2: PRINTER ON/OFF. It is assumed the printer is be assigned to LPT1:. When the printer is set ON, all important output is printed on the screen and echoed to the printer.

Choices 8, 9, and 10: MODIFY DATA.

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Data may be edited with choice 8: individual values or weighting factors may be changed, new data points may be added, or points that are clearly incorrect may be deleted. Choice 9 allows the *X* and *Y* values to be scaled by a constant. Choice 10 zeros all data and parameters to begin a new problem.

Choice 14: LIST. This option allows the user to review or print all the current data and parameters before or after modifying the data. Function key F3 is used to abort the listing. LIST also displays the Fit Minus Measurement (FMM) value for each data point, allowing the user to determine which data points (if any) are poorly represented by the fitted function. If the fitted function represents the data perfectly, the FMM value for each point will equal zero.

Choice 15: SAVE ON DISK. This option saves all the current data and parameter values, using the chosen title. The program displays the disk directory of the data drive and then asks for the new file name. It is up to the user to check that the new file name does not duplicate one already on the disk; if it does, the existing file will be overwritten by the new file. This feature is useful when long fitting problems are concerned. It may be desirable to discontinue fitting, run some other program, and then continue fitting later. Pressing F3 will pause the program after the current iteration, and selecting choice 15 will save the data and parameter values for later use.

Choice 16: READ FROM DISK. This option reads back all data stored with the SAVE option. Once the data have been read back from disk, choice 3: SOLVE may be selected or changes can be made to the parameters. If those changes do not improve the fit, it is possible to go back to the saved data and start again.

Table 2 highlights the major segments of the program. The following paragraphs present a sketchy overview of the algorithm found in lines 6000 through 7130. A detailed presentation of the mathematics involved in this fitting routine is beyond the scope of this article. However, for those interested, Schreiner and Jenkins' article in *X-ray Spectrometry* (volume 8, number 1, 1979) and Marquardt's article in *Journal of the Society for Industrial and Applied Mathematics* (volume 11, 1963) provide an in-depth explanation.

As mentioned earlier, the iterative method starts out with an initial set of parameters. For each iteration, a new set of values is calculated by computing the change vector, ΔP, and adding it to the old parameter set. In the program, ΔP is stored in the array named *G*. This array is found by inverting the following equation

$$A(I) * G(I) = -GRAD(I)$$

where A(I) is a matrix computed from the derivatives of the function with respect to the parameters, PARM(I). GRAD(I) is proportional to the gradient of the sum of squares with respect to each parameter. The values of G(I) are obtained by inverting the matrix, A, and multiplying:

$$G = A^{-1} * GRAD$$

Each iteration executes lines 6240 and 6820. Lines 6550 through 6680 compute the values of G(I), and lines 6700 through 6780 update the PARM(I) values. Convergence is tested in lines 6790 and 6870. If convergence has not yet been reached, the program continues to lines 6830 through 6860 to consider what value to use for Lambda in the next iteration. This process is then repeated. When convergence is reached, the program branches to line 6890 to find the parameter errors by in-

verting a matrix; it then computes various statistical functions.

The program allows space for as many as 30 independent parameters and 500 data points. If more than one independent variable, *X*, is needed, additional arrays (*X1*, *X2*, etc.) of dimension 500 can be allocated. If memory is a problem, the number of data points can be decreased and the variable MXOBS% can be redefined. Finally, the routine can be used to fit linear functions as well as nonlinear ones. Convergence will be fast, but, more than one step will be required because of the approximations explained earlier.

The original FORTRAN version of the program solved the computer-game problem in three seconds on a Data General Nova 4/X with integer hardware multiply/divide. The IBM BASIC (interpreter) version took 46 seconds. If the program is compiled using the IBM BASIC Compiler version 1.0, this speed increases dramatically to 6.6 seconds. (A further doubling of speed is obtained by adding an 8087 coprocessor with appropriate software support). As can be seen, the compiled program is on a par with a large minicomputer and can be used as a practical scientific tool.

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LISTING 1: MARQFIT.BAS

```
1 ' PROGRAM MARQFIT.BAS -- a non-linear least squares fitting
2 ' routine using the marquardt algorithm
5 ' (c) 1985 W. Schreiner, M. Kramer, S. Krischer, & Y. Langsam
20 '-------------- initialize program settings --------------
30  REV = 2.1 : PI = 3.14159265#
40  ON ERROR GOTO 19000 : RETCOD = 0 :KEY OFF
60  DEF SEG=64:POKE 23,(PEEK(23) OR 64): DEF SEG 'set caps lock
65  ' The values MXVAR%, MXOBS% and MDI% can be changed-
70  ' be sure to change the DIM sizes correspondingly
80  MXVAR% = 30:MXOBS% = 500 : MDI% = MXVAR% * (MXVAR% + 1) / 2
90  DIM X(500),DTA(500),WGT(500),FXP(500),FYP(500),XP(500)
100 DIM YP(500),C(465),A(465),B(30),DPARM(30),PARM(30),
        KFIX(30),DERIV(30),G(30),GRAD(30)
110 DEF FNLGT(X) = LOG(X)/LOG(10)
120 ON KEY(1) GOSUB 10200 : ON KEY(2) GOSUB 10300
130 ON KEY(3) GOSUB 10310 : ON KEY(4) GOSUB 10400
140 KEY(1) ON : KEY(2) ON : KEY(3) ON : KEY(4) ON
160   FG=2:BG=0:FG1=14:BG1=0:FG2=4:BG2=0 ' color attributes
165 FOR I = 1 TO MXOBS% : WGT(I) = 1 : NEXT
190 ' --------------plot routine initialization
200 PLOTSET% = 0 ' plot definition flag
210 XTOTAL.PIX = 639: YTOTAL.PIX = 199
220 ' (for lo_res use XTOTAL.PIX = 319)
230 ' XMIN.PIX is lower left hand xmin in pixel coords;
240 ' YMIN.PIX is lower left hand ymin in pixel coords;
250 ' XMIN and YMIN are the same but in USER coordinates
260 XMIN.PIX=CINT(.11*XTOTAL.PIX): XMAX.PIX=.94*XTOTAL.PIX
270 YMAX.PIX=CINT(.07*YTOTAL.PIX)-2: YMIN.PIX=YTOTAL.PIX-12
280 DELTAX.PIX = XMAX.PIX-XMIN.PIX+1
290 DELTAY.PIX = YMIN.PIX-YMAX.PIX+1
310 ' functions to convert X & Y in user coords --> pixel coords
320 DEF FNSX(N)=XMIN.PIX + CINT((N-XMIN)*DELTAX.PIX/(XMAX-XMIN))
330 DEF FNSY(N)=YMIN.PIX - CINT((N-YMIN)*DELTAY.PIX/(YMAX-YMIN))
335 ' ----------------------start up----------------------
340 IPFLG = 0    ' pause-in-fitting flag
350 ISVFL =  - 1 ' data saved flag
360 CLS : LOCATE 10 : COLOR FG2,BG2 :
    PRINT TAB(15) "MARQUARDT LEAST SQUARES - REV ";REV:
365 COLOR FG,BG : FOR I = 1 TO 1700: NEXT:LOCATE 20
370 INPUT "USE DATA ON DRIVE (ENTER LETTER):";DRV$:
    DRV$ =LEFT$(DRV$,1) : IF DRV$ <> "" THEN DRV$=DRV$+":"
380  GOTO 420
390  ' ---------------------  menu  ------------------------
400  PRINT "PRESS ANY KEY TO CONTINUE":WHILE INKEY$ = "":WEND
410  RETCOD = 0 ' reset error flag
420  F1%=0:SCREEN 0 :CLS: GOSUB 10000: COLOR FG2,BG: LOCATE 1,20
425  PRINT "MENU OPTIONS:": COLOR FG,BG : PRINT:COLOR FG1,BG1
430  PRINT TAB(6) "GENERAL:";:COLOR FG,BG
435  PRINT TAB(21) "1- ENTER TITLE " 'line  800
440  PRINT  TAB(21) "2- PRINTER ";   'line  850
450  IF PFLG% = 0 THEN PRINT "ON/";:COLOR FG1,BG1:PRINT  "OFF":
     COLOR FG,BG ELSE COLOR FG1,BG1: PRINT "ON";: COLOR FG,BG : PRINT  "/OFF"
460  PRINT  TAB(21) "3- SOLVE "      'line  900
470  PRINT  TAB(21) "4- PLOT "       'line  15000
480  PRINT  TAB(21) "5- QUIT "       'line  1300
490  PRINT  : COLOR FG1,BG1:PRINT  "    ENTER DATA:";:
     COLOR FG,BG:PRINT TAB(21) "6- MANUAL" 'line 1400
500  PRINT  TAB(21) "7- UREAD"       'line 1800
510  PRINT
520  COLOR FG1,BG1:PRINT  "    MODIFY DATA:";:COLOR FG,BG:
     PRINT TAB(21) "8- EDIT"         'line 2000
530  PRINT  TAB(21) "9- SCALE"       'line  2200
540  PRINT  TAB(20) "10- ZERO"       'line  2400
550  PRINT:COLOR FG1,BG1:PRINT "    PARAMETERS:";:COLOR FG,BG:
     PRINT TAB(20) "11- ENTER/REVIEW/CHANGE"     'line 2500
570  PRINT  "                    12- FIX"        'line  2800
580  PRINT  "                    13- FREE"       'line  3000
590  PRINT
600  COLOR FG1,BG1:PRINT  "    DATA & PARAM: ";:COLOR FG,BG:
     PRINT "14- LIST "     ' line 3200
610  PRINT  "                    15- SAVE ON DISK" 'line 3400
620  PRINT  "                    16- READ FROM DISK" 'line 3600
630  COLOR 15,BG: INPUT; "ENTER CHOICE";KMND:COLOR FG,BG:PRINT
650  ON KMND+1 GOTO 420,800,850,900,15000,1300,1400,1800,2000,
     2200,2400,2500,2800,3000,3200,3400,3600
660  PRINT  "*** ERROR *** ";KMND;" INVALID COMMAND": GOTO 400
800 'enter a title for documentation -----------------------
810 INPUT "ENTER TITLE: ";TITL$:LOCATE 25,1:PRINT TITL$;SPC(11)
820  GOTO 420
850 'toggle printer on/off ----------------------------------
860 PFLG% = 1 - PFLG%: GOTO 420
900 'solve the mrqdt non-linear lst sq fit problem ------------
920 ITER% = 0 : IF IPFLG <  > 0 THEN ITER% = NITER%
930 IPFLG = 0:ISVFL = 0 : CLS : GOSUB 10000
```

```
940 INPUT "HOW MANY ITERATIONS? ";MXITER%
950 IF MXITER% < 0 THEN MXITER% = 0
960 GOSUB 6000 ' go fit !
970 IPFLG = - 1 : NITER% = NITER% + ITER%
990 PRINT:PRINT: PRINT TITL$ :PRINT NITER%;" ITERATIONS": PRINT
1000 IF PFLG% = 1 THEN LPRINT:LPRINT TITL$
     :LPRINT NITER%;" iterations "
1010 GOSUB 9000
1020 IF FLG%=1 THEN PRINT:PRINT "CHOLESKY NEGATIVE DIAGONAL--";
          "UNABLE TO  SOLVE WITH SUPPLIED INITIAL PARAMETERS"
1030 PRINT  : PRINT  "PRESS ANY KEY FOR FITTING STATISTICS"
1040 WHILE INKEY$ = "" : WEND
1050 GOSUB 1100 : PRINT : GOTO 400 'print statistics and return
1070 'print fit statistics ---------------------------------
1100 PRINT  : PRINT  "SOME FITTING STATISTICS:"
1110 PRINT "SIGMA= ";SIG;" R= ";R;: PRINT TAB( 41);
                                "WGT'D SUM OF SQ. = ";WSS
1120 CHI2 =  INT (10 * CHI2) / 10
1130 PRINT  "CHI SQUARED= ";CHI2;" / ";NF;" DEG OF FREEDOM"
1140 PRINT  "# OF CALLS TO SUM OF SQ=";NSSC;:
          PRINT TAB( 41);"# OF DERIV CALLS=";NDC:
          PRINT  "# INC IN LAMBDA=";INCR;" LAMBDA= ";LAMBDA
1150 IF PFLG% <> 1 THEN RETURN
1160 LPRINT : LPRINT  "SOME FITTING STATISTICS:"
1170 LPRINT  "SIGMA= ";SIG;" R= ";R;:
      LPRINT TAB( 41);"WGT'D SUM OF SQ. = ";WSS
1180 LPRINT  "CHI SQUARED= ";CHI2;" / ";NF;" DEG OF FREEDOM"
1190 LPRINT "# OF CALLS TO SUM OF SQ=";NSSC;:
     LPRINT   TAB( 41);"# OF DERIV CALLS=";NDC:
     LPRINT  "# INC IN LAMBDA=";INCR;" LAMBDA= ";LAMBDA
1200 RETURN
1300 'quit -----------------------------------------------
1310  IF ISVFL <  > 0 THEN 1360
1320  INPUT "PRESENT DATA NOT SAVED. SAVE IT?? (Y/N)";T1$
1330  IF  LEFT$ (T1$,1) = "Y" THEN 3400 'go save
1340  IF  LEFT$ (T1$,1) <> "N" THEN 420
1360 DEF SEG=64:POKE 23,(PEEK(23) AND 191):DEF SEG 'clear caps
1370  CLS: END
1400  'manual data entry ----------------------------------
1410  PRINT  "MANUAL DATA ENTRY - ": PRINT  "  (, TO EXIT)"
1412 ' set flags to indicate data points that currently exist
1415 FOR K=1 TO NOBS%:XP(K)=1:NEXT :
     FOR K = NOBS%+1 TO MXOBS%:XP(K)=0:NEXT
1420 PRINT  "POINT    X,MEASUREMENT"
1425 PRINT  "===== ====,==========="
1430 FOR I = 1 TO MXOBS%
1440    PRINT  I;: INPUT " ";T1$,T2$
1450    IF T1$ = "" THEN NOBS% = I - 1: GOTO 1480
1460    X(I) =  VAL (T1$):DTA(I) =  VAL (T2$) :XP(I) = 1
1470 NEXT
1480 INPUT "WEIGHTS-ENTER 'NO','STAT' OR 'EXPLICIT'?";T1$
1490 IF T1$ = "NO" THEN FOR I=1 TO NOBS%:WGT(I)=1:NEXT:GOTO 1580
1500 IF T1$ = "STAT" THEN
       FOR I = 1 TO NOBS%: WGT(I)=SQR (DTA(I)): NEXT : GOTO 1580
1510 IF T1$ <  > "EXPLICIT" GOTO 1480
1520 PRINT  : PRINT  "POINT     X      Y      WEIGHT":
          PRINT  "=====  =====  =====   ======"
1530 FOR I = 1 TO NOBS%
1540    PRINT  I;"      ";X(I);"     ";DTA(I);"     ";WGT(I);
1550    INPUT "New Weight=";WGT$:IF WGT$="" THEN 1570
1560    WGT(I) = VAL(WGT$)
1570 NEXT
1580 NOBS% = 0 : PRINT  "NOW ORDERING & REVIEWING DATA"
1600 FOR I = 1 TO MXOBS%
1610    IF XP(I) = 0 GOTO 1650  'zero it if pt is to be deleted
1620    NOBS% = NOBS% + 1
1630    X(NOBS%) = X(I):DTA(NOBS%) = DTA(I):WGT(NOBS%) = WGT(I)
1640    IF I <  > NOBS% THEN XP(I) = 0
1650 NEXT
1680 IPFLG = 0:ISVFL = 0 : GOTO 420
1800 'user defined read routine ----------------------------
1810 PRINT "NO USER DEFINED ROUTINE IMPLEMENTED"
1820 GOTO 400
2000 'edit data -------------------------------------------
2005 FOR K=1 TO NOBS%:XP(K)=1:NEXT
2010 FOR K = NOBS%+1 TO MXOBS%:XP(K)=0:NEXT
2015 PRINT "ENTER 'W' TO CHANGE ONLY WEIGHTS,";:
                 INPUT "'D' TO CHANGE DATA & WEIGHTS";T1$
2020 IF T1$ = "W" GOTO 1480
2030 PRINT "ENTER DATA PT RANGE FOR EDITING (N1,N2)"
2040 INPUT "(, TO EXIT)";T1$,T2$
2050 IF T1$ = "" GOTO 1580
2060 I =  VAL (T1$):J =  VAL (T2$)
2070 IF I<1 OR J>MXOBS% THEN PRINT "INVALID RANGE":GOTO 2030
2080 FOR K = I TO J
```

```
2090     PRINT  "CURRENT VALUE OF X,DTA,WGT FOR PT #";K;" =":
            PRINT X(K);"  ";DTA(K);"  ";WGT(K)
2100     PRINT  "ENTER NEW VALUE FOR X(";K;")"
2105     PRINT "(ENTER 'D' TO DELETE PT, OR 'enter' ";:
         INPUT "TO LEAVE UNCHANGED)";T1$
2110     IF T1$ = "D" THEN XP(K) = 0: GOTO 2150
2120     IF T1$ = "" THEN 2150
2130     X(K) =  VAL (T1$) : XP(K) = 1
2140     INPUT "ENTER NEW VALUES FOR DTA,WGT ";DTA(K),WGT(K)
2150 NEXT
2160 GOTO 2030
2200 'scale x,dta,wgt ------------------------------------
2210 INPUT "ENTER X-COORDINATE SCALE FACTOR";XSCALE
2220 INPUT "ENTER DATA POINT SCALE FACTOR";DSCALE
2230 INPUT "ENTER WEIGHT SCALE FACTOR";WSCALE
2240 FOR I = 1 TO NOBS%
2250 X(I)=X(I)*XSCALE:DTA(I)=DTA(I)*DSCALE:WGT(I)=WGT(I)*WSCALE
2280 NEXT
2290 IPFLG = 0:ISVFL = 0 : GOTO 420
2400 'zero data & parameters ----------------------------------
2410 FOR I=1 TO MXOBS%:X(I)=0:DTA(I)=0:WGT(I)=0:NEXT:NOBS% = 0
2420 FOR I=1 TO MXVAR%:PARM(I)=0:DPARM(I) = 0: NEXT :NPRM% = 0
2430 IPFLG = 0:ISVFL =  - 1 : GOTO 420
2500 'enter/review/change param ------------------------------
2510 CLS:GOSUB 9000 : IF NPRM% < 1 THEN 2580
2530 PRINT  "CHANGE PARAMETERS? ENTER:   'A' TO CHANGE ALL":
    PRINT TAB(29)"'S' TO SELECTIVELY CHANGE (or add parameters)"
2540 PRINT TAB(29) "press RETURN to leave unchanged";:INPUT T1$
2550 IF T1$ = "" GOTO 420
2560 IF T1$ = "S" THEN 2700
2570 IF T1$ <  > "A" THEN 2530
2580 PRINT "ENTER PARAMETERS ONE AT A TIME.":
         PRINT "   (NULL TO EXIT)"
2590 FOR I = 1 TO MXVAR%
2600     PRINT  I;"- "; : INPUT T$ : PRINT
2610     IF T$ = "" THEN NPRM% = I - 1: GOTO 2660
2620     IF  LEFT$ (T$,1) = "." OR LEFT$ (T$,1) = "-" THEN 2640
2630     IF  LEFT$.(T$,1) < "0" OR  LEFT$ (T$,1) > "9" THEN
           PRINT T$ "INVALID, RETYPE": GOTO 2600
2640     PARM(I) =  VAL (T$)
2650 NEXT
2660 IF NPRM% <  = 0 GOTO 420
2670 FOR I = 1 TO NPRM%:DPARM(I) = 0: NEXT
2680 IPFLG = 0 : ISVFL = 0 : GOTO 420
2700 '----- change some of the param
2710 PRINT "ENTER PARM#, AND VALUE": PRINT SPC(10)"(, TO EXIT)"
2720 INPUT T1$,T2$: IF T1$ = "" THEN  GOSUB 9000: GOTO 400
2730 IF VAL(T1$) = NPRM%+1 THEN NPRM%=NPRM%+1
2740 IF  VAL (T1$) < 1 OR  VAL (T1$) > NPRM% THEN
         PRINT "INVALID PARM#. RANGE IS 1-";NPRM%+1: GOTO 2720
2750 IF  LEFT$ (T2$,1) = "." OR LEFT$ (T2$,1) = "-" THEN 2770
2760 IF  LEFT$ (T2$,1) < "0" OR  LEFT$ (T2$,1) > "9" THEN
         PRINT T2$ "INVALID, RETYPE": GOTO 2720
2770 PARM( VAL (T1$)) =  VAL (T2$)
2780  GOTO 2720
2800 'fix some parameters -----------------------------------
2810 GOSUB 9000
2820 IF NPRM% < 1 THEN 400
2830 INPUT "ENTER PARM# TO BE FIXED (NULL TO EXIT)";I
2840 IF I = 0 GOTO 2870
2850 IF I<1 OR I>NPRM% THEN PRINT "INVALID PARM#. RANGE IS 1-"
        ;NPRM%: GOTO 2800
2860 KFIX(I) = 1 : F1% = 1 : GOTO 2830
2870 IF F1% = 0 GOTO 400 'NOTHING CHANGED
2880 GOSUB 9000 : IPFLG = 0:ISVFL = 0 : GOTO 400
3000 'free some previously fixed param.-----------------------
3010 GOSUB 9000 : IF NPRM% < 1 THEN 400
3030 INPUT "ENTER PARM# TO BE FREED (NULL TO EXIT)";I
3040 IF I = 0 GOTO 3070
3050 IF I < 1 OR I > NPRM% THEN
        PRINT  "INVALID PARM#. RANGE IS 1-";NPRM%: GOTO 3000
3060 KFIX(I) = 0 : F1% = 1 : GOTO 3030
3070 IF F1% = 0 GOTO 400
3080 GOSUB 9000 : IPFLG = 0:ISVFL = 0 : GOTO 400
3200 'print data and param values ----------------------------
3210 CLS:GOSUB 10000:PRINT "MARQUARDT LEAST SQUARES - REV ";REV
3220 PRINT  TITL$: PRINT  NITER%;" ITERATIONS": PRINT
3230 IF PFLG%=1 THEN LPRINT TITL$:LPRINT NITER%;" ITERATIONS"
3240 GOSUB 9000 : GOSUB 1100 'print parameters and statistics
3260 PRINT:PRINT NOBS%;" DATA POINTS BEING FITTED":
       PRINT SPC(18)"(X,DTA,WGT,FMM)"
3270 IF PFLG%=1 THEN LPRINT:LPRINT NOBS%;
   " DATA POINTS BEING FITTED":LPRINT SPC(18) "(X,DTA,WGT,FMM)"
3280 IF NOBS% <  = 0 GOTO 3360
3290 PFORM$ = "##.##^^^^   "
```

```
3300 FOR I = 1 TO NOBS%
3310 IF BRKFLG% THEN BRKFLG% = 0:PRINT "BREAK IN LISTING":
     GOTO 400
3320 GOSUB 20000:FMM = FUNCTN - DTA(I)
3330 PRINT USING PFORM$;X(I),DTA(I),WGT(I),FMM
3340 IF PFLG%=1 THEN LPRINT USING PFORM$;X(I),DTA(I),WGT(I),FMM
3350 NEXT
3360 GOTO 400
3400 'save data  & parameters ------------------------------
3410 PRINT  "THESE ARE YOUR CURRENT FILES" : FILES DRV$ + "*.*"
3430 PRINT  : INPUT "SAVE DATA AS DISK FILE NAMED ";T1$
3435 IF MID$(T1$,2,1) <> ":" THEN T1$ = DRV$ + T1$
3440 OPEN "O",2,T1$ : IF RETCOD <> 0 THEN CLOSE 2 : GOTO 400
3460 WRITE #2, TITL$ : WRITE #2, NOBS%
3470 FOR I = 1 TO NOBS%: WRITE #2, X(I),DTA(I),WGT(I): NEXT
3480 WRITE #2, NPRM%
3485 FOR I = 1 TO NPRM%:WRITE #2, PARM(I),DPARM(I),KFIX(I):NEXT
3490 CLOSE 2: IPFLG = 0:ISVFL =  - 1 : GOTO 420
3600 'read data & param from disk --------------------------
3610 PRINT "THESE ARE YOUR CURRENT FILES" : FILES DRV$ + "*.*"
3630 PRINT:INPUT "READ DATA & PARAM FROM DISK FILE NAMED ";T1$
3635 IF MID$(T1$,2,1) <> ":" THEN T1$ = DRV$ + T1$
3640 OPEN "I",3,T1$ : IF RETCOD <> 0 THEN CLOSE 3 : GOTO 400
3660 INPUT #3, TITL$ : INPUT #3, NOBS%
3670 FOR I = 1 TO NOBS%: INPUT #3, X(I),DTA(I),WGT(I): NEXT
3680 INPUT #3, NPRM%
3685 FOR I = 1 TO NPRM%:INPUT #3, PARM(I),DPARM(I),KFIX(I):NEXT
3690 CLOSE 3
3700 IPFLG = 0:ISVFL =  - 1:GOSUB 9000:PRINT
3705 LOCATE 25,1:PRINT TITL$;:LOCATE 21 : PRINT  : GOTO 400
4000 'subroutine to compute chi-squared ---------------------
4010 CHI2 = 0
4020 FOR I = 1 TO NOBS%
4030    IF WGT(I) = 0 THEN 4060
4040    GOSUB 20000
4050    CHI2 = CHI2 + ((FUNCTN - DTA(I)) / WGT(I)) ^ 2
4060 NEXT
4070 RETURN
4500 'subroutine obtains CHOLESKY backward solution of matrix A
4510 G(1) = G(1) / A(1)
4520 IF NFIT% <  = 1 THEN 4630
4530 L = 1
4540 FOR I = 2 TO NFIT%
4550    K = I - 1
4560    FOR J = 1 TO K
4570       L = L + 1 : G(I) = G(I) - A(L) * G(J)
4590    NEXT
4600    L = L + 1 : G(I) = G(I) / A(L)
4620 NEXT
4630 MDI% = NFIT% * (NFIT% + 1) / 2
4640 G(NFIT%) = G(NFIT%) / A(MDI%)
4650 IF NFIT% <  = 1 THEN  RETURN
4660 FOR K1 = 2 TO NFIT%
4670    I = NFIT% + 2 - K1
4680    K = I - 1 : L = I * K / 2
4700    FOR J = 1 TO K
4710       G(J) = G(J) - G(I) * A(L + J)
4720    NEXT
4730    G(K) = G(K) / A(L)
4740 NEXT
4750 RETURN
5000 'subroutine to perform CHOLESKI decomposition of matrix a
5010 FLG% = 0
5020 FOR J = 1 TO NFIT%
5030    L = J * (J + 1) / 2
5040    IF J <  = 1 THEN 5120
5050    FOR I = J TO NFIT%
5060       K1 = I * (I - 1) / 2 + J  : F = A(K1) : K2 = J - 1
5090       FOR K = 1 TO K2:F = F - A(K1 - K) * A(L - K): NEXT
5100       A(K1) = F
5110    NEXT
5120    IF A(L) > 0 THEN 5160
5130    FLG% = 1 : PRINT "CHOLSKI-NEG DIAG J,L,A(L)= ";J,L,A(L)
5150    RETURN
5160    F =  SQR (A(L))
5170    FOR I = J TO NFIT%
5180       K2 = I * (I - 1) / 2 + J :  A(K2) = A(K2) / F
5200    NEXT
5210 NEXT
5220 RETURN
5500 'subroutine to calculate the weighted sum of squares ------
5510 WSS = 0 : NSSC = NSSC + 1
5520 FOR I = 1 TO NOBS%
5530    GOSUB 20000
5540    WSS = WSS + (WGT(I) * (FUNCTN - DTA(I))) ^ 2
5550 NEXT
```

```
5570 RETURN
5700 'subroutine to calculate the sum of squares -------------
5710 SS = 0 : NSSC = NSSC + 1
5720 FOR I = 1 TO NOBS%
5730     GOSUB 20000 : SS = SS + (FUNCTN - DTA(I)) ^ 2
5750 NEXT
5770 RETURN
5900 'subroutine to calculate the sum of DTA(I)^2 ------------
5910 R = 0
5920 FOR I = 1 TO NOBS% : R = R + DTA(I) ^ 2 : NEXT
5950 RETURN
5990 'subroutine to do the main mathematics of the fitting -----
6000 NFIT% = 0:NX% = 0
6010 IF NPRM% < 1 THEN RETURN 2500
6020 FOR I = 1 TO NPRM%
6030     IF KFIX(I) = 0 GOTO 6070
6040     NX% = NX% + 1
6050     DPARM(NX%) = 0!
6060     GOTO 6090
6070     NFIT% = NFIT% + 1
6080     B(NFIT%) = PARM(I)
6090 NEXT
6100 IF NFIT% <= 0 THEN NITER% = ITER% : RETURN 420
6140 'perform MARQUARDT fitting -------------------------------
6150 IF NOBS% >= NFIT% THEN 6180
6160 PRINT  "# OF DATA PTS (NOBS%= ";NOBS%;")";" IS LESS THAN";
        TAB( 41);"# OF PARAM. TO BE FIT (NFIT%= ";NFIT%;")"
6165 PRINT  "MODEL IS UNDETERMINED"; CHR$ (7)
6170 NITER% = ITER% : RETURN 400
6180 PRCSN = 2.5E-07 : LAMBDA = .01 : LMIN = 1E+20 : PHI = 1
6190 MDI% = NFIT% * (NFIT% + 1) / 2
6200 NSSC = 0 : NDC = 0 : NITER% = 0 : INCR = 0
6210 GOSUB 5500 ' Choleski decomposition
6220 PRINT "WGT'D SSQ = ";WSS
6225 IF PFLG%=1 THEN LPRINT "WGT'D SSQ = ";WSS
6230 GOTO 6280
6240 'NEXT ITERATION ------------------------------------------
6250 NITER% = NITER% + 1
6260 IF (NITER% > 4 AND LAMBDA < LMIN) THEN LMIN = LAMBDA
6270 LOCATE ,13: PRINT  WSS : IF PFLG% = 1 THEN LPRINT WSS;" ";
6280 IF NITER% >= MXITER%
      THEN PRINT  MXITER%;" ITERATIONS - PAUSE": GOTO 6920
6290 IF BRKFLG%
      THEN BRKFLG% = 0 : PRINT "OPERATOR INTERRUPT": GOTO 6920
6300 COLOR FG2,BG2 : PRINT  "COMPUTING ";: COLOR FG1,BG1
6305 PRINT " ITERATION #";NITER% + 1;: COLOR FG,BG:PRINT
6310 '------- DECREASE LAMBDA
6320 LAMBDA = .31622777# * LAMBDA : INCR = 0
6340 '------- CALCULATE A=JTJ AND JTF
6350 FOR I = 1 TO MDI%:A(I) = 0: NEXT
6360 FOR I = 1 TO NFIT%:GRAD(I) = 0: NEXT
6370 FOR I = 1 TO NOBS%
6380     GOSUB 21000
6390     FMM = (F - DTA(I)) * WGT(I)
6400     J = 0
6410     FOR K = 1 TO NPRM%
6420         IF KFIX(K)=0 THEN J = J+1:DERIV(J) = DERIV(K)*WGT(I)
6430     NEXT
6440     FOR J = 1 TO NFIT%
6450         GRAD(J) = GRAD(J) + DERIV(J) * FMM
6460         L = J * (J - 1) / 2
6470         FOR K=1 TO J: A(L+K)=A(L+K)+DERIV(J)*DERIV(K): NEXT
6480     NEXT
6490  NEXT
6500  NDC = NDC + 1
6510 '------ SAVE "A" MATRIX AND CURRENT PARAMETER VALUES "B"
6520 FOR I = 1 TO MDI%:C(I) = A(I): NEXT
6530 FOR I = 1 TO NFIT%:DERIV(I) = B(I): NEXT
6540 '------ DOCTOR "A" MATRIX DIAGONAL ELEMENTS TO BE:
6550 '       A = A(1+LAMBDA) + PHI*LAMBDA
6560 DA = PHI * LAMBDA
6570 FOR J = 1 TO NFIT%
6580     G(J) =  - GRAD(J)
6590     L = J * (J + 1) / 2
6600     A(L) = C(L) * (1 + LAMBDA) + DA
6610     K = J - 1
6620     IF K > 0 THEN  FOR I = 1 TO K:A(L - I) = C(L - I): NEXT
6630 NEXT
6650 GOSUB 5000  'Cholesky decomposition
6660 IF FLG% <> 0 GOTO 6840
6680 GOSUB 4500   'calculate g (the change in parameters)
6690 '------ FIND NEW PARAMETERS B = D+G
6700 '       (NO COUNTS THE # OF ZERO ELEMENTS IN G)
6710 NO = 0 : I = 0
6720 FOR J = 1 TO NPRM%
6730     IF KFIX(J) <  > 0 GOTO 6780
```

```
6740     I = I + 1
6750     B(I) = DERIV(I) + G(I)
6760     IF  ABS (G(I)) <= ABS (PRCSN*DERIV(I)) THEN NO = NO + 1
6770     PARM(J) = B(I)
6780  NEXT
6790  IF NO = NFIT% GOTO 68,0
6800  OLDWSS = WSS : GOSUB 5500  'update the wss
6820  IF WSS < OLDWSS GOTO 6250  'next iteration
6830 '------ last step too big; increase lambda
6840 IF LAMBDA < PRCSN THEN LAMBDA = PRCSN
6850 INCR = INCR + 1
6860 LAMBDA = 10! * LAMBDA
6870 IF LAMBDA <  = 100000! * LMIN GOTO 6560
6880 '------ convergence reached
6890 RI = LAMBDA / LMIN
6900 CLS : GOSUB 10000 : PRINT  "      CONVERGENCE  REACHED "
6905 PRINT  "# OF PARAMS FIT = ";NFIT%
6907 PRINT  "# OF PARAMS CONVERGED = ";NO
6910 PRINT  "LAMBDA/L(MIN) = ";RI
6920 NF = NOBS% - NFIT%
6930 IF NF <  = 0 GOTO 6990
6940 GOSUB 5700  'calc sum of squares
6950 SIG =  SQR (SS / NF)
6960 GOSUB 5900   'calc sum of dta^2
6970 R =  SQR (SS / R) * 100!
6980 GOSUB 4000   'compute chi-squared
6990 IF NITER% <= 0 GOTO 7130
7000 FOR J = 1 TO MDI%:A(J) = C(J): NEXT : GOSUB 5000
7010 IF FLG% = 0 GOTO 7060
7020 FOR J = 1 TO NPRM%
7030     IF KFIX(J) = 0 THEN PARM(J) = 999.0001
7040 NEXT
7050 GOTO 7130
7060 K = 0
7070 FOR I4 = 1 TO NPRM%
7080     IF KFIX(I4) <> 0 GOTO 7120
7090     K = K + 1
7100     FOR J = 1 TO NFIT%:G(J) = 0!: NEXT :G(K) = 1!
7110     GOSUB 4500:DPARM(I4) =  SQR ( ABS (G(K))) * SIG
7120 NEXT
7130 RETURN
9000 'list the current values of the parameters ---------------
9010 IF NPRM% < 1 THEN  PRINT  "NO PARAM ENTERED": RETURN
9020 PRINT
9025 PRINT NPRM%; " FITTING PARAMETERS & THEIR ERRORS" : PRINT
9030 IF PFLG%= 1 THEN LPRINT : LPRINT NPRM%;
                  " FITTING PARAMETERS AND THEIR ERRORS":LPRINT
9040 FOR I = 1 TO NPRM%
9050     IF PFLG% = 0 GOTO 9080
9060     LPRINT  I;") ";PARM(I);
9070     IF KFIX(I) = 0 THEN  LPRINT  " +- ";DPARM(I)
                        ELSE LPRINT "  (FIXED)  "
9080     PRINT  I;") ";PARM(I);
9090     IF KFIX(I) = 0 THEN  PRINT  " +- "; DPARM(I)
                        ELSE PRINT "  (FIXED)  "
9100 NEXT
9110 PRINT : RETURN
9999 ' ---------- FUNCTION KEY and HELP SUBROUTINES ----------
10000 'display "help" / title line ---------------------------
10005 XCURSOR = CSRLIN : YCURSOR = POS(0) : LOCATE 25,1
10010 IF SHOWTITLE THEN COLOR FG2,BG:PRINT  TITL$;
      ELSE COLOR FG2,BG : PRINT " 1- SHOW FUNCTION KEYS";
      "   2- SHOW TITLE   3- BREAK   4- QUICK-PLOT";:COLOR FG,BG
10020 LOCATE XCURSOR,YCURSOR : RETURN
10200 SHOWTITLE=0: GOSUB 10000: RETURN 'display "HELP" line---F1
10300 SHOWTITLE = -1: GOSUB 10000: RETURN 'display title -----F2
10310 BRKFLG% = 1 : RETURN  'user interrupt (break function) -F3
10400 CLS : PRINT TAB(15); "QUICK PLOT" ' ------------------F4
10410 PRINT TAB(10); " Y "; YSTYL$; " VS."; " X ";XSTYL$;" PLOT"
10420 IF PLOTSET% = 0 THEN
        PRINT "PLOT NOT DEFINED - FIRST USE MENU OPTION #4" :
       PRINT"PRESS ANY KEY TO CONTINUE":WHILE INKEY$="":WEND:
      RETURN
10430 GOSUB 16000   'scale data log or linear
10440 GOSUB 16300   'calculate fitting function
10450 IF XNEG THEN
        PRINT "WARNING: NEGATIVE X VALUE. X LOG PLOT INVALID":
        XNEG=0:GOTO 10470
10460 GOSUB 16500 ' PLOT
10470 SCREEN 0 : RETURN
15000 'Plot data points and fitting function -----------------
15010 'Plot data points and fitting function -----------------
15020 CLS
15030 IF NPRM% < 1 AND NOBS% < 1 THEN PRINT  TAB(20),
              "NO DATA POINTS OR PARAMETERS ENTERED":GOTO 400
```

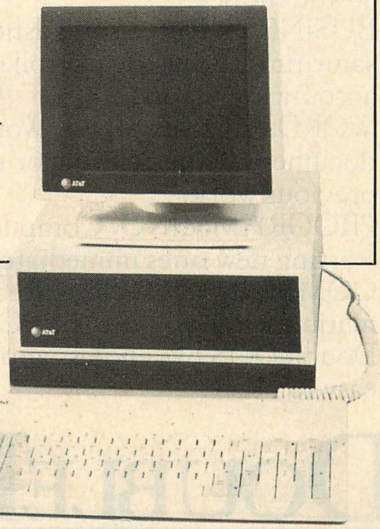
```
15040 FOR I = 1 TO NPRM%
15050    IF PARM(I) < > 0 THEN GOTO 15080
15060 NEXT
15070 PRINT "      WARNING: all parameters are currently = 0"
15080 RESPLOT = 0    'FLAG to indicate plot for residuals
15090 IF NOBS% < 1 THEN GOTO 15170
15100 PRINT TAB(15),"CHOOSE PLOT:":PRINT
15110 PRINT " 1- PLOT DATA AND FITTING FUNCTION"
15120 PRINT " 2- PLOT RESIDUALS [ABS(FIT MINUS MEASUREMENT)]"
15130 PRINT " 3- PLOT RESIDUALS [% FIT MINUS MEASUREMENT]"
15140 INPUT "ENTER CHOICE:";KMND
15150 IF KMND = 2 THEN RESPLOT = 1 : PCNT% = 0
15160 IF KMND = 3 THEN RESPLOT = 1 : PCNT% = 1
15170 PRINT TAB(15),"CHOOSE GRAPH STYLE:"
15180 PRINT "1-   Y LINEAR VS. X LINEAR"
15185 PRINT "2-   Y LINEAR VS. X LOG"
15190 IF RESPLOT = 1 GOTO 15210
15200 PRINT "3-   Y LOG VS. X LINEAR":PRINT "4-   Y LOG VS. X LOG"
15210 OLDSTYL%=GSTYL%:PRINT:INPUT "ENTER CHOICE:";GSTYL%
15220 IF GSTYL% = 0 THEN 400
15230 IF GSTYL% <> OLDSTYL% THEN PLOTSET% = 0
15240 XSTYL$="LINEAR"
15245 IF (GSTYL%=2 OR GSTYL%=4) THEN XSTYL$="LOG"
15250 YSTYL$="LINEAR"
15255 IF (GSTYL%=3 OR GSTYL%=4) THEN YSTYL$="LOG"
15260 CLS:PRINT TAB(15);" Y ";YSTYL$;" VS.";" X ";XSTYL$;" PLOT"
15270 IF NOBS% <1 THEN 15460
15280 ' GO SCALE THE DATA INTO PLOTTING ARRAY
15290 GOSUB 16000   'scale determine minimum and maximum of DTA
15300 IF XNEG THEN
        PRINT "WARNING: NEGATIVE X VALUE. X LOG PLOT INVALID":
        XNEG=0:GOTO 15170
15320 PRINT : PRINT  "DATA POINTS: "
15330 PRINT  "X VALUES range from: ";XP(1);" to ";XP(NOBS%)
15340 PRINT  "Y VALUES range from: ";MINDTA;" to ";MAXDTA
15350 IF PLOTSET% = 0  THEN 15420
15360 PRINT "Current graph boundaries are:"
15370 PRINT "       xmin = ";XMIN;"  xmax = ";XMAX
15380 PRINT "       ymin = ";YMIN;"  ymax = ";YMAX
15390 PRINT:PRINT
      " Do you wish to change any of the graph boundaries (Y/N)"
15400 INPUT "(null to leave unchanged)";T1$
```

```
15410 IF T1$ = "" OR T1$ = "N" THEN 15460
15420 PRINT:INPUT "ENTER GRAPH XMIN,XMAX,YMIN,YMAX ";
              XMIN,XMAX,YMIN,YMAX
15425 IF XMIN = 0 AND XMAX = 0 GOTO 420
15430 PRINT:PRINT "ENTER xinterval,yinterval";
               "(THE # OF INTERVALS ON THE x,y AXIS)";
15435 INPUT XINTERVAL, YINTERVAL
15440 PLOTSET% = 1
15450 IF RESPLOT = 1 OR NPRM%=0
      THEN XINC = 2*(XMAX-XMIN)/MXOBS%:GOTO 15720
15460 PRINT:PRINT "PLOT OF FITTED FUNCTION";
               "(FROM CURRENT VALUE OF PARAMETERS):"
15470 IF NOBS% < 1 AND PLOTSET% = 0 GOTO 15530
15480 PRINT "The function will be plotted in the range ";
                                    XMIN; " to ";XMAX
15490 INPUT "ENTER X INCREMENT for plotting the function";XINC
15500 IF XINC <=0 THEN PRINT "INVALID ENTRY":GOTO 15480
15510 IF (XMAX-XMIN)/XINC > MXOBS% THEN PRINT
      "too many points, must be fewer than ";MXOBS%: GOTO 15480
15520 GOTO 15570
15530 PRINT "      NO DATA CURRENTLY ENTERED"
15540 PRINT:PRINT "ENTER XMIN,XMAX AND X-INCREMENT"
15550 INPUT "for evaluating fitting function";XMIN,XMAX,XINC
15560 IF (XMAX-XMIN)/XINC > MXOBS% THEN PRINT
      "too many points, must be fewer than ";MXOBS%: GOTO 15530
15570 GOSUB 16300 ' evaluate function
15580 PRINT:PRINT "MINIMUM of fitted function= ";MINYP
15590 PRINT "MAXIMUM of fitted function= ";MAXYP
15600 PRINT:PRINT "current graph boundaries are:"
15610 PRINT "       xmin = ";XMIN;"  xmax = ";XMAX
15620 PRINT "       ymin = ";YMIN;"  ymax = ";YMAX
15630 IF NOBS%<1 THEN 15670
15640 PRINT
15645 PRINT "do you wish to change THESE GRAPH BOUNDARIES?(Y/N)"
15650 INPUT "(null to leave unchanged)";T1$
15660 IF T1$ = "" OR T1$ = "N" THEN 15720
15670 PRINT:PRINT "ENTER NEW YAXIS BOUNDARY VALUES -- YMIN,YMAX"
15680 INPUT "(ENTER , TO CHANGE ALL GRAPH BOUNDARIES)";T1$,T2$
15690 IF T1$ = "" THEN 15420
15700 YMIN = VAL(T1$):YMAX = VAL(T2$)
15710 PRINT: PRINT "ENTER xinterval,yinterval";
               " (THE # OF INTERVALS ON THE x,y AXIS)"
```

```
15715 INPUT XINTERVAL, YINTERVAL
15720 GOSUB 16500 'go and plot
15730 SCREEN 0 : GOTO 420   'finished plotting
16000 'Scale data & find the minima and maxima of data in YP(I)
16010 XNEG = 0
16020 MINDTA = 9.999999E+37: MAXDTA = -9.999999E+37
16030 FOR I = 1 TO NOBS%
16040 XP(I) = X(I): YP(I) = DTA(I)
16050 IF RESPLOT <> 1 THEN 16090
16060 NORM = DTA(I):IF NORM = 0 THEN NORM = 1E-10
16070 GOSUB 20000: YP(I) = FUNCTN - DTA(I) 'yes - calc residuals
16080 IF PCNT% <>0 THEN YP(I) = YP(I)/NORM ' plot % residual?
16090 IF (GSTYL%=1 OR GSTYL%=3) GOTO 16110 ' xlog plot?
16100 IF X(I)>0 THEN XP(I) = FNLGT(XP(I)) ELSE XNEG = 1 : RETURN
16110 IF (GSTYL%=1 OR GSTYL%=2) GOTO 16130 ' ylog plot?
16120 IF DTA(I)>0 THEN YP(I)=FNLGT(YP(I)) ELSE YP(I) = YMIN
16130 IF YP(I) >= MAXDTA THEN MAXDTA = YP(I)
16140 IF YP(I) <= MINDTA THEN MINDTA = YP(I)
16150 NEXT
16160 RETURN
16290 'calculate function using current parm values ----------
16300 PRINT:PRINT "CALCULATING FUNCTION...."
16305 IF NPRM% < 1 THEN RETURN
16310 I=0: KK=0: MINYP = 9.9E+37: MAXYP = -9.9E+37
16320 FOR XPT=XMIN TO XMAX STEP XINC
16330     KK=KK+1: FXP(KK) = XPT
16340     X(I) = XPT :IF (GSTYL%=1 OR GSTYL%=3) GOTO 16360
16350     X(I)=10^XPT ' FOR X-LOG PLOT
16360     GOSUB 20000
16370     FYP(KK) = FUNCTN 'FOR NON-LOG Y PLOT
16380     IF (GSTYL%=1 OR GSTYL%=2) GOTO 16400
16390     IF FUNCTN > 0 THEN FYP(KK)=FNLGT(FUNCTN)
                 ELSE FYP(KK) = YMIN
16400     IF FYP(KK) >= MAXYP THEN MAXYP = FYP(KK)
16410     IF FYP(KK) <= MINYP THEN MINYP = FYP(KK)
16420 NEXT XPT
16430 KMAX = KK
16440 RETURN
16500 'plotting subroutine -- first axes and tick marks -------
16510 DELTAX = XMAX-XMIN: DELTAY = YMAX-YMIN: LETWID=8: LETHGT=8
16515 'hi-res screen & choose color 2 -for pc & 100% compatibles
16520 SCREEN 2:DEF SEG = &H0: OUT &H3D9,2
16530 LINE (XMIN.PIX,YMIN.PIX) - (XMAX.PIX,YMAX.PIX),,B
16540 IF XINTERVAL < 1 THEN XINTERVAL = 5
16550 ' X TICKS
16560 MINCOL = 0
16570 FOR TICK = 0 TO XINTERVAL
16580     TICKPLACE = XMIN.PIX + CINT(DELTAX.PIX*TICK/XINTERVAL)
16590     LINE(TICKPLACE,YMIN.PIX-2) - (TICKPLACE,YMIN.PIX+2)
16600     LINE(TICKPLACE,YMAX.PIX-2) - (TICKPLACE,YMAX.PIX+2)
16610     TICCOL = INT(TICKPLACE/LETWID)-1
16620     VAL.LAB = XMIN + (TICK/XINTERVAL)*DELTAX
16630     IF (GSTYL%=2 OR GSTYL%=4) THEN VAL.LAB = 10^VAL.LAB
16640     TICLAB = VAL.LAB:GOSUB 18000
16650     TICCOL = TICCOL - LEN(FORMAT$)/2 + 2
16660     IF TICCOL + LEN(FORMAT$) > 80 THEN 16700
16670     IF TICCOL < MINCOL GOTO 16700
16680     LOCATE 25,TICCOL: MINCOL = TICCOL + LEN(FORMAT$)
16690     PRINT USING FORMAT$;TICLAB;
16700 NEXT TICK
16710 IF YINTERVAL < 1 THEN YINTERVAL = 5
16720 ' Y TICKS
16730 OLDROW = 26
16740 FOR TICK = 0 TO YINTERVAL
16750     TICKPLACE = YMIN.PIX - CINT(DELTAY.PIX*TICK/YINTERVAL)
16760     LINE(XMIN.PIX-2,TICKPLACE) - (XMIN.PIX+2,TICKPLACE)
16770     LINE(XMAX.PIX-2,TICKPLACE) - (XMAX.PIX+2,TICKPLACE)
16780     TICROW = INT (TICKPLACE/LETHGT) + 1
16790     IF TICROW >= OLDROW-1 THEN GOTO 16860
16800     VAL.LAB = YMIN + (TICK/YINTERVAL) * DELTAY
16810     IF (GSTYL%=3 OR GSTYL%=4) THEN VAL.LAB = 10^VAL.LAB
16820     TICLAB = VAL.LAB :GOSUB 18000
16830     TICCOL = 8 - LEN(FORMAT$):IF TICCOL < 1 THEN TICCOL=1
16840     LOCATE TICROW,TICCOL : OLDROW = TICROW
16850     PRINT USING FORMAT$;TICLAB;
16860 NEXT TICK
17000 'plot points and function ------------------------------
17010 FOR I = 1 TO NOBS%
17020    CIRCLE (FNSX(XP(I)),FNSY(YP(I))),4
17030 NEXT
17040 IF RESPLOT = 1 OR NPRM% < 1 GOTO 17120 ' no function plot
17050 IWENT%=0
17060 FOR K = 1 TO KMAX
17070    XPT = FNSX(FXP(K)): YPT = FNSY(FYP(K))
```

```
17080    IF XPT<0 OR XPT>XTOTAL.PIX OR YPT<0 OR YPT>YTOTAL.PIX
           THEN 17110 ' pt out of range
17090    IF IWENT% = 0 THEN PSET (XPT,YPT) : IWENT%= 1
17100    LINE -(XPT,YPT)
17110 NEXT K
17120 GTITL$ = TITL$: PCNT$ = "": IF PCNT% = 1 THEN PCNT$="(%)"
17130 IF RESPLOT = 1 THEN GTITL$ = GTITL$+" - RESIDUALS"+PCNT$
17140 LOCATE 1,50-LEN(GTITL$):PRINT GTITL$;
17150 WHILE INKEY$ = "" : WEND : RETURN
18000 'subroutine to format a label for axis ------------------
18020 FORMAT$="#"
18030 IF TICLAB=0 THEN RETURN
18040 ORDER=INT(LOG(ABS(TICLAB))/2.30258)
18050 IF ABS(ORDER)>=4 THEN FORMAT$ = "##.#^^^^" : RETURN
18060 IF ORDER<0 THEN FORMAT$=FORMAT$+".": GOTO 18080
18070 FORMAT$=FORMAT$+STRING$(ORDER+1,"#")+"."
18080 T=TICLAB
18090 TOL=ABS(TICLAB/100000!)
18100  FP=ABS(T-FIX(T)): IF 1-FP<FP THEN FP=1-FP
18110 WHILE FP>TOL
18120   T=T*10: TOL=TOL*10
18130   FP=ABS(T-FIX(T)): IF 1-FP<FP THEN FP=1-FP
18140   FORMAT$=FORMAT$+"#"
18150 WEND
18160 RETURN
19000 'error trap ------------------------------------------
```

```
19010 IF RETCOD = 0 THEN RETCOD = -1 :ERRCNT = 1: GOTO 19030
19020 ERRCNT = ERRCNT + 1 ' error flagged again in same routine
19030 IF ERR=5 THEN PRINT "ILLEGAL FUNCTION CALL"
19040 IF ERR=6 THEN PRINT "OVERFLOW ERROR"
19050 IF ERR=53 OR ERR=54 THEN PRINT "FILE NOT FOUND"
19060 IF ERR=61 THEN PRINT "DISK FULL ERROR"
19070 IF ERR=70 OR ERR=71
         THEN PRINT "DISK NOT READY OR WRITE PROTECTED"
19080 PRINT "ERROR #";ERR;" ON LINE NUMBER ";ERL
19090 IF ERRCNT > 5 THEN PRINT:PRINT
           "ROUTINE TERMINATING DUE TO ERROR COUNT ": GOTO 400
19100 PRINT "PRESS ANY KEY TO CONTINUE...":WHILE INKEY$="":WEND
19110 RESUME NEXT
20000 'subroutine to evaluate the function chosen to be fit
20005 'The function code here is for the video game problem
20010 FUNCTN = PARM(1) * (1 - EXP(-PARM(2) * X(I)))
20020 RETURN
20050 '
21000 'subroutine to evaluate the derivative of the function
21005 'with respect to each parameter. Only 2 parameters here.
21010 GOSUB 20000
21020 F = FUNCTN
21030 DERIV(1) = F / PARM(1)
21040 DERIV(2) = X(I) * (PARM(1)-F)
21050 RETURN
```



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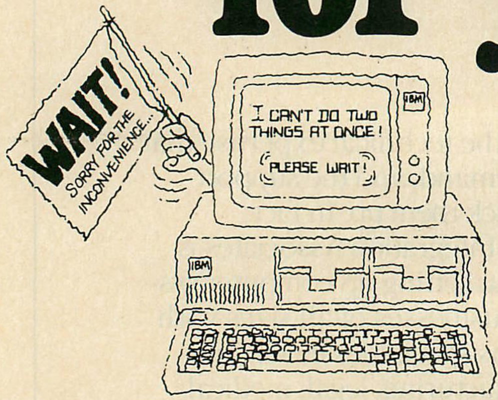

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System/34 for the Microcomputer

BABY/34 transports the System/34 minicomputer operating environment to the PC, PC/XT, and PC/AT.

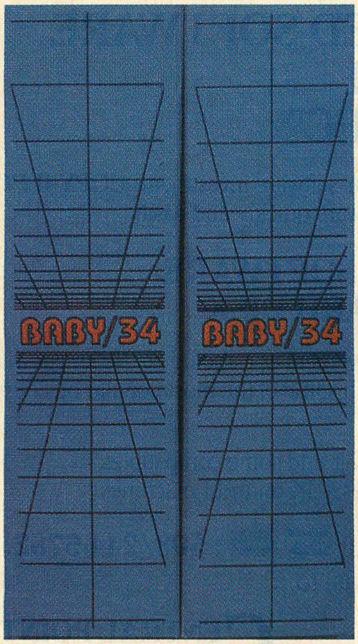
ROBERT SANFORD

The operating environment of the IBM System/34 minicomputer is now available to IBM PC users via a new product from California Software Products, Inc. BABY/34 is a fairly complete software system that transports most of the IBM System/34 environment to the PC. It is designed to match the System/34 in the use of the RPG II compiler (see sidebar), OCL (Operation Control Language), SORT, SEU (an editor), SFGR (Screen Format Generator), and DFU (Data File Utility). With BABY/34, users who are familiar with the System/34 can rapidly and easily move their programs to the PC.

Because of this complete environment, the minimum machine configuration is a PC with 256KB of memory, DOS 2.0 or later, a parallel port, and two 360KB drives. A hard disk is highly recommended. The latest version of the system (version 2.2) also has been tested on the PC/AT and DOS 3.0.

The RPG II compiler is written in Pascal to make it easier to modify to keep current with new IBM development. An OCL interpreter is included to interpret each line of control language as is done on the System/34, and a sophisticated sort facility allows data sorting exactly as a System/34. The only major program that is not available is the Screen Design Aid. Specifications for a screen are entered using the editor.

The package that arrives from California Software Products includes two thick binders, a documentation update, five diskettes, and a software protection device. The first binder contains the RPG II and DFU reference manuals. The second one covers installation, OCL,



SEU, DEU (Data Exchange Utility), and SORT. Also included is a concise summary of the key differences between the System/34 RPG II and BABY/34 implementation (see accompanying sidebar).

The documentation is very complete and well cross-referenced. Each section contains appendices with documentation of the runtime messages and other reference information.

The instructions for the software protection device are quite clear. It plugs into the parallel printer port, and the printer plugs into it. This device is supposed to be transparent to the system, nevertheless the user is warned not to send bit-mapped graphics to the printer while using BABY/34. The software protection device eliminates the need to copy-protect the diskettes.

Installation of BABY/34 on a PC/XT also is explained clearly and in some detail in the documentation. After the first diskette is inserted, the user types "INSTALL <drive letter:>." A menu is displayed asking for the diskette drive ID, the hard disk ID, and the subdirectory in which the programs are to be placed. After entering this data, the proper subdirectories are created, and the system is copied and verified.

The system occupies about 1.3MB, but much of that is unnecessary code. For example, the source code for the screen editor formats is included in the event that the user wants to modify them. The installation section appendix has both tailoring and sizing considerations to enable a user to shrink the system to the minimum configuration. BABY/34 can be run on a PC with floppy disk drives alone, but this is not recommended for development.

Disk organization in System/34 is different from a PC. In the System/34,

PHOTOGRAPH • STEVE BORNS

libraries are special files that contain programs (called *members*). Data files and libraries share the disk in a single directory. BABY/34 emulates this by putting all data files in the \RPG subdirectory and creating additional subdirectories for the System/34 libraries. This is a very workable solution.

PROGRAM CONVERSION

Conversion of System/34 from one machine to another is a large task. First the programs and data must be physically moved to the new machine and reformatted to the target machine requirements. If the target machine uses different character representation, appropriate translation must be done to both the source code and the data files. All programs must be modified if the code is dependent upon the character representation. This last step can be a huge investment in programmer time, unless the compiler does the conversion internally. The Baby/34 compiler was written with character set conversion in mind and handles most ASCII/EBCDIC differences by internally converting some items to EBCDIC, doing the operation, and converting to ASCII. The documentation shows which items are handled by the compiler, and which must be analyzed by the programmer.

BABY/34 was tested by transporting a major system containing more than 100 RPG programs, 50-plus screens and menus, and related procedures. First, the libraries were transported from the System/34 to the PC. Since a library on the System/34 is a file containing multiple members, it must be brought to the PC, split into multiple source files, and converted from EBCDIC to ASCII. The DEU documentation explains clearly the steps to be taken on the System/34 to build the diskette files.

The editor, SEU, has a flaw in file recovery that will annoy System/34 users who are used to that system's strong file recovery capabilities.

For this test, a Flagstaff Engineering eight-inch diskette drive was attached to the PC. DEU automatically splits the source file into multiple members and converts to ASCII. It also determines if the source member is a screen or an RPG program and attaches the appropriate suffix to the resulting file on the PC. All of this is done without any user effort. DEU also simplifies translating data files from EBCDIC to ASCII. As each file is translated, DEU asks for the conversion requirements. All fields except packed decimal and binary should be converted to ASCII. The conversion requirements are easy, but a help screen is available if necessary.

At this time in the testing process, more than 100 source files needed to be recompiled. To speed this process, a directory of the source members was run, the output was redirected to a data file, and an editor was used to set up a large procedure, or batch, file. OCL started the runtime interpreter, called the procedure, and the OCL interpreter was left to run on its own overnight. It read the procedure, ran the compiler and screen generator, and produced runtime programs and listings. The next morning only a few programs had failed to compile and the errors were easily identified and corrected.

Next came the test: would BABY/34 run the System/34 RPG II programs on a PC? Yes. However, when the data were keyed the carriage return key did not perform as the Field Exit key of the System/34; it worked more like a New Line key. According to the documentation, BABY/34 handles the keyboard either way. If KEY5251 is put in the AUTOEXEC.BAT file (or entered prior to entering the BABY/34 system) BABY/34 remaps the keyboard to the familiar IBM 5251 terminal keyboard.

BABY/34 has some very nice capabilities in addition to transporting programs from System/34. SEU, DEU, the RPG II compiler, and SFGR may also be called from DOS. In addition, DOS.BAT files may be executed from within the OCL interpreter. If the interpreter cannot find a file with the .P suffix, it looks for a .BAT file with the same name but proceeded by a "$". If it finds this file, it executes it as a DOS batch file and returns automatically to the interpreter when finished.

OCL can be called from within the interpreter. This is similar to calling COMMAND.COM from within COMMAND.COM. The interpreter loads another copy of itself. When signing off of this level, the user is returned to the previous level. Although this is not considered a bug, each time the interpreter is loaded, 65KB is used up.

Screens do not automatically clear at the end of a procedure in BABY/34. This can also be circumvented, but is annoying and not System/34-standard.

The editor, SEU, has a flaw in file recovery that will annoy System/34 users who are accustomed to the strong file recovery capabilities of that system. SEU automatically builds two work files while editing. One contains the original lines of code; the other contains any added lines. If the program ends unexpectedly, SEU will attempt to recover these files the next time it is called. A disaster was simulated by rebooting. The file had been added to the directory, but since it was not closed correctly, the data were lost. CHKDSK /F was used to recover the data. This is really a DOS problem rather than an SEU problem. Since this is not part of the normal operation, it did not pose a serious problem, however.

Apart from minor annoyances, the BABY/34 system seems very robust and easy to use. Errors are handled gracefully, and nothing in normal operation caused the system to crash. The documentation is very good and the technical support outstanding. Designing a compatible compiler and operating system that simulate another compiler and operating system working on a different computer is an exceedingly difficult task. As the other vendor releases new enhancements and changes its standards, the package must be updated. In addition, as more and more programs are brought across to the PC environment, more bugs are found that are traceable not to errors in how the compiler works, but to differences in the way the compiler handles various default conditions. Many times these defaults are undocumented features in the original system. By using these features, the programmers may make their own code nonportable to other machines.

California Software Products seems committed to enhancing BABY/34 as necessary to keep it current with the System/34 line and to resolve conflicts with the IBM standard. Currently, there are more than 3,000 registered users of BABY/34. Although this product is not a complete implementation of the System/34 environment, it is more than enough to make the transition from the System/34 to the PC a fairly easy task.

Pricing of BABY/34 depends upon user requirements. The runtime-only package is $650. This does not include the DFU execution module, which is available for $150. A runtime system with SEU, DEU, and DFU is $1,650. A development system that includes everything except the DFU program generator is $2,700, with the DFU generator available for an additional $600. All of these prices include a full year of maintenance support from California Software Products. Although these prices may seem high, the cost of reprogramming existing IBM System/34 software in another language for the IBM PC would be far higher.

BABY/36 is undergoing final product review and should be available by the time this article is published. It incorporates all of the BABY/34 functions plus expanded functional support of unique System/36 features. Pricing will be similar to that for the BABY/34, beginning at $700 for the runtime-only version with DFU. A development system with everything will be $3,500.

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Santa Ana, CA 92701
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CIRCLE 449 ON READER SERVICE CARD

Robert Sanford, chairman of Hotel Information Systems, Inc., has spent more than 15 years in hotel management and software development for hotels. He has used the IBM System /3, /32, /34, /36, and /38 to write five major hotel software systems.

THE STRENGTH OF RPG II

At first glance the RPG II programming language seems obsolete, cumbersome, and decidedly not state-of-the-art. Nonetheless, most of the IBM Systems /3, /32, /34, and /36 today still use RPG II as their primary language. Since hundreds of thousands of these machines are in use, RPG II has become a major language. The overwhelming success of the System/3, followed by the Systems /32, /34, and /36, gave RPG II credibility. In addition, the standards have always been rigidly defined by IBM.

The RPG II programming language began originally as the Report Program Generator on the IBM System/360 in the 1960s. At that time the language was easy to use, but limited to producing batch reports. When the IBM System/3 minicomputer line was introduced by the General Systems Division in 1969, the language was extensively modified and enhanced to become RPG II. It was also the only language available on the System/3. As the System/3 line was expanded, the language was further enhanced with new features and functions for the new machines.

An advantage to using RPG II is that a new programmer can produce dependable working code in a far shorter time than almost any other language. RPG II moves most of the housekeeping functions from the programmer to the compiler. A general logic cycle is automatically built to include opening files, reading records into buffers, moving data between buffers and fields, writing buffers to disk, and closing files. This frees the programmer to concentrate on calculations, rather than design.

RPG II has a series of very powerful indicators (flags), some of which are automatically controlled by the internal logic of the program; others are left for use by the programmer. They may be used to control which record to read next, which fields to bring in from the buffer to the work area, which fields on the screen to reverse-image, or which fields to write to disk. An indicator may be set as the result of an operation and determine whether a line code is executed hundreds of lines later.

The programmer also is helped by a series of coding sheets. Unlike other coding sheets, these are unique to the data required. Information about files is filled in on a file specification sheet and calculations are written on a calculation sheet. Because of these specification sheets, the source input is not free-form. For example, the programmer must put an *F* in column 6 of the file spec sheet. The file name must begin in column 7. The source must be entered in the correct order. Program header specifications must be first, followed by file specs, input specs, calculations, and finally, output specs. This rigidity leads to frustration (and derision) from programmers migrating to RPG II from other languages and is part of the reason RPG II is held in low repute. This rigidity, however, makes the source listings far easier to read and debug.

The standard RPG II logic cycle is quite simple. The program reads a record, does calculations, and writes a record. This repeats until no more records exist for that file. The cycle starts again with the next file listed. The programmer can short-circuit this at any time by turning on a special indicator to signal end-of-job. In truth, the logic cycle is much more sophisticated than this. Records may be read alternately from two files. In addition, output may be performed if a *level-break* has occurred. This allows the programmer to print totals and clear work fields automatically if the contents of a field change.

The logic cycle works on records rather than fields. This record may be a disk record or a record from a workstation (CRT) or some other device. A record from a workstation may be a full screen of data, rather than a single keystroke. The programmer does not have to contend with the character or field I/O, only with record I/O.

The programmer may deviate from the normal logic cycle. For example, the cycle may be interrupted to get data through a READ or a CHAIN command. The READ operation gets the next sequential record, while the CHAIN operation gets an indexed or direct file record based upon a key value or record number. Normal output is modified through the EXCPT operation. This allows the programmer to interrupt the calculations, write a record (or display a message), and return to the next line.

Since all records in RPG II have fixed field and record lengths, the language supports three basic types of disk files: indexed, direct, and sequential. In addition, a file that is created as indexed may still be accessed as a direct or sequential file. This gives the programmer flexibility in approaching any new task.

The strength of RPG II on the System/34 is enhanced by a complete system support structure that includes a full range of program utilities, a control language to control scheduling and execution of programs, a screen design aid, and a program editor closely tied to the language.

—ROBERT SANFORD

BABY/34 DIFFERENCES

SSP/OCL—SYSTEM SUPPORT PROGRAM/OPERATION CONTROL LANGUAGE

- The major difference between BABY/34 and System/34 is one of single-user versus multitasking. BABY/34 has no job queue and no ability to evoke a task. Tasks placed in the job queue or that are evoked will execute immediately. Neither does BABY/34 have a background "server" task. System/32 users will be familiar with this ability.
- Most of System/34's utility programs are included in BABY/34; others can be duplicated using DOS.
- Some OCL statements and parameters are not applicable. A configuration option allows these statements to be ignored if encountered.
- Periods in file names on the System/34 are changed to an underline character on BABY/34.
- Group files are not implemented on BABY/34.
- Data must be passed as OCL parameters and not as data.
- Data may be passed to the program through the local data area or through the PROMPT function.

SEU—SOURCE ENTRY UTILITY

- The Home key will backspace only if the cursor is in the first position of the screen. Since this field is almost always an auto-dup field, this function is not usable much of the time.
- Syntax checking is not implemented in BABY/34. A help capability is, however, that displays the required data for each field in the current format.
- BABY/34 has no ability to access members in other libraries. Members must be in the current library.
- No special action is taken at EOJ for procedures.
- The INSERT key to BABY/34 does not put the terminal

into insert mode, but merely shifts all of the data in that field to the right one position.

SORT

- The collating sequence is ASCII, so an alternate collating sequence statement may be required in BABY/34.
- Sorts based upon bit values or zone/digit may be different because of ASCII.
- A maximum of 65,535 records may be sorted in one file in BABY/34.
- Sort requires an input record length in the header specification if the output length and input length are different (because DOS does not supply this information).

RPG II

- Since BABY/34 data are in ASCII instead of EBCDIC, some programming changes may be required. BABY/34 does some runtime conversions automatically, so changes are far fewer than would be required to convert to another RPG compiler using ASCII. An example of conversion required is a TESTB (test bit) operation on a numeric field to determine the sign. This could be changed to Z-ADD to make it compatible with both ASCII and EBCDIC. The system automatically converts characters to their EBCDIC equivalent for testing in cases such as MOVE and input record selection. The BABY/34 manual is very helpful in showing programming that must be examined.
- Inquiry is not supported.
- BABY/34 ignores program identification in column 75. The object name is the same as the source name.
- Delete-capable direct files are not supported.
- Indexed files are always IFILE type. Keysort is not required and added index entries are available.
- BABY/34 has no communications support or special device support.
- The EXIT opcode is limited to SUBR21 and SUBR23. BABY/34 cannot link to user-written subroutines.
- The DEL operation in the output specification is not supported.
- ACQ, POST, NEXT, and SORTA are not implemented and produce compiler errors in BABY/34.
- RUF (read under format) is supported, but not very usable in a runtime system. When a program terminates, keystrokes are kept in an internal buffer and not written to the screen until the next program is loaded. Thus, there is no operator feedback. This is acceptable for testing and debugging.
- BABY/34 has no AUTO REPORT capability.
- There is no capability for MRT or NEP programs (since the operating system is single-user).

SFGR—SCREEN FORMAT GENERATOR

- SFGR works like it does in the System/34 with the exception of some display attributes not available on the PC. The Screen Design Aid (SDA) is not available.
- Fields on the screen are limited to 80 characters.
- Column separators are emulated with underline.

DFU—DATA FILE UTILITY

- All functions work as they do on the System/34.

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Pascal Bugs

Both IBM and Microsoft Pascal compilers suffer from some serious bugs, but the user can work around them.

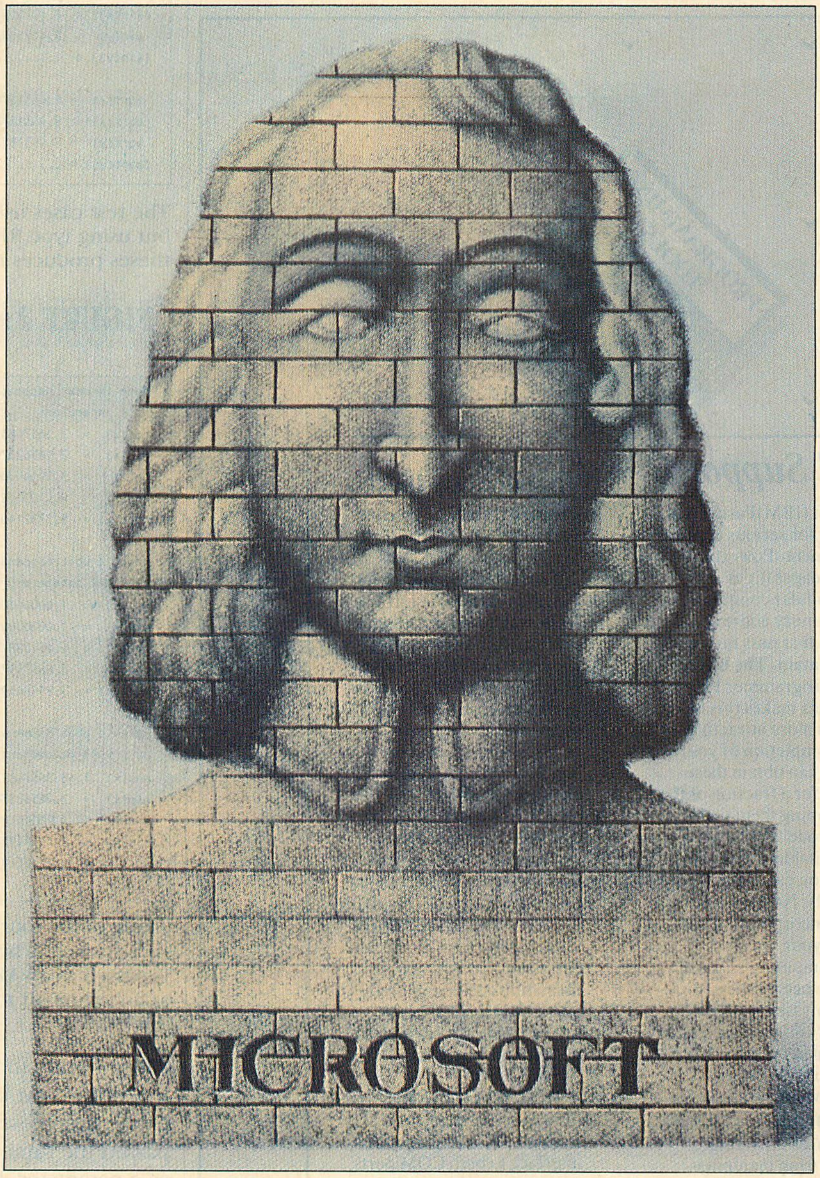

ILLUSTRATION • TIM CURRY

TED FORGERON

During the two and one-half years between the release of IBM Pascal version 1.0 in August 1981 and version 2.0 in March 1984, Microsoft released, on the average, one new version of the compiler every six to nine months. It's no secret that Microsoft developed both versions of the IBM Pascal compiler, but because IBM does not have the exclusive marketing rights to the compiler, Microsoft's enhanced, intermediate versions were available to the public before the equivalent IBM version was released.

Sometimes, however, it pays to wait. The Pascal compiler has at least five serious bugs. Four involve support for floating point (REAL) numbers and one involves double-word (INTEGER4) integers. The most serious bug of the five prevents Pascal programs that use

real numbers from running on the PC/AT. Because IBM subjected the compiler to additional, intensive testing after taking delivery from Microsoft, at least two of these problems, which exist in MS-Pascal 3.2, are not present in the equivalent IBM Pascal 2.0.

But even IBM is fallible. Two of the more fatal bugs described in this article exist in IBM's latest version as well.

All of the bugs described here were tested on four different versions of the Pascal compiler: IBM versions 1.0 and 2.0 and Microsoft versions 3.13 and 3.2. For IBM Pascal version 1.0, the test programs were linked with the standard PASCAL.LIB. For the three newer Pascal compiler versions, the test programs were linked with their respective 8087 emulator math libraries.

Bug 1: Extra parentheses. Some programmers like to use extra parentheses to make their code more readable. However, extra parentheses enclosing expressions that include variables of type REAL8 may produce surprising results.

Listing 1 contains a program called BUG1 that displays the output of several Pascal library functions. In BUG1, each function is invoked with and without extra parentheses. The functions are passed the same floating-point number as a parameter. In one set of function calls, the parameter is declared REAL4 (the normal 32-bit REAL in Pascal). In the other set of calls, the parameter is declared REAL8. REAL8 corresponds to the 64-bit IEEE format and provides more precision than REAL4.

Figure 1 shows the output from BUG1 after it was compiled with MS-Pascal 3.13 and linked with the 8087

FIGURE 1: *BUG1 Results*

```
   cos(x)  =  5.414222000E-01
 (cos(x))  =  5.414222000E-01
   cos(y)  =  5.41422863E-001
 (cos(y))  =  ...............

   exp(x)  =  1.333700000E+24
 (exp(x))  =  1.333700000E+24
   exp(y)  =  1.33370098E+024
 (exp(y))  =  1.21026209E+039

    ln(x)  =  4.017283000E+00
  (ln(x))  =  4.017283000E+00
    ln(y)  =  4.01728352E+000
  (ln(y))  =  1.20335381E+299

   sin(x)  = -8.407508000E-01
 (sin(x))  = -8.407508000E-01
   sin(y)  = -8.40750428E-001
 (sin(y))  =  ...............

  sqrt(x)  = 7.453187000E+00
 (sqrt(x)) = 7.453187000E+00
  sqrt(y)  = 7.45318724E+000
 (sqrt(y)) = ...............
```

The test cases using REAL4 are correct, but using type REAL8 with extra parentheses produces incorrect results.

FIGURE 2: *BUG3 Results*

```
Here is what happens when x is not passed
as a parameter:
cos(x)  =  -3.36574832E-001
exp(x)  =   2.98562378E+014
ln(x)   =   3.50645789E+000
sin(x)  =   9.41656722E-001
sqrt(x) =   5.77321401E+000

Here is what happens when x is passed
as a VAR parameter:
cos(x)  =   1.00000000E+000
exp(x)  =   1.00000000E+000
ln(x)   =  -4.45402213E+002
sin(x)  =   3.66671177E-194
sqrt(x) =   1.91486599E-097

Here is what happens when x is passed
as a VARS parameter:
cos(x)  =  -3.36574832E-001
exp(x)  =   2.98562378E+014
ln(x)   =   3.50645789E+000
sin(x)  =   9.41656722E-001
sqrt(x) =   5.77321401E+000
```

Three of the four compilers give incorrect answers when a REAL8 variable is passed as a VAR parameter and used as an argument to a library function.

emulator version of PASCAL.LIB. Notice that the test cases using REAL4 all give the correct answers. But when the parameter is of type REAL8 and extra parentheses surround the function, the results are dreadfully wrong.

This bug was fixed in MS-Pascal 3.2 and does not appear in either of the IBM versions of the compiler.

Bug 2: Assignment of REAL nested variables. MS-Pascal 3.2 gives the wrong answer if REAL variables are used in an assignment statement and the variables are declared in a procedure at a higher level of nesting than the procedure that contains the assignment statement. This sounds more complicated than it really is. An example will help explain it. In listing 2, the program BUG2 contains two procedures, INNER and OUTER. The two REAL variables *x* and *y* are declared in OUTER. The procedure INNER includes an assignment statement to assign the contents of *y* to *x*.

PAS2 of MS-Pascal 3.2 fails to generate the correct machine code for this assignment statement. Whereas *x* and *y* should both equal 77.77, *x* equals 9.758847000E-37, and *y* equals 7.777000000E+01. Fortunately, there is an easy way around this bug.

Listing 3 is a program to force the compiler to generate the correct code for the troubled assignment statement. The problem disappears if *y* is moved out to the program (or module) level, thereby making it static.

This bug does not exist in earlier versions of MS-Pascal or in either IBM version. Microsoft claims that it has fixed this bug in version 3.3.

Bug 3: REAL VAR parameters to library functions. When a REAL8 variable is passed to a procedure as a VAR parameter and then used as an argument for a REAL library function, all but one version of the compiler fall apart. Not surprisingly, the version of Pascal that holds together in this situation is also the oldest, IBM Pascal 1.0. This is because IBM 1.0 predates support for double-precision floating-point (REAL8) numbers.

Listing 4 shows what happens when REAL8 variables are passed as VAR parameters. Figure 2 gives the results. This problem can be bypassed by always declaring REAL8 parameters as VARS instead of VAR. VARS forces the compiler to pass the complete segmented address of the parameter to the procedure, whereas VAR lets the compiler pass only the 16-bit offset.

Bug 4: Multiplication results assigned to double-word INTEGER. Sometimes within Pascal, it is more convenient to use a WORD variable instead of an INTEGER variable to hold a number. If the number to be stored will never be negative, the obvious reason for using a WORD is that it can hold a value twice as large as an INTEGER. The largest number that can be stored in a WORD is 65,535, whereas the largest number that can be stored in an INTEGER is 32,767.

Another way to store larger numbers is with the data type INTEGER4. An INTEGER4 variable is four bytes (two words) long. The normal INTEGER and WORD types are only two bytes (one word) long. When WORD, INTEGER4, and multiplication were mixed in the same assignment statement, three out of the four Pascal compilers tested here generated incorrect machine code for the statement:

```
X := W * 10000;
```

where X is a variable of type INTEGER4 and W is of type WORD.

Figure 3 shows the code that the compilers generated for this assignment statement (the line numbers and comments shown here are mine).

FIGURE 3: *Code Generated from Assignment Statement*

```
1   MOV    AX,2710H    ; AX = 10000
2   MUL    W           ; MULTIPLY W * 10000
3   XOR    DX,DX       ; CLEAR THE HIGH WORD OF THE ANSWER
4   MOV    X,AX        ; LOW WORD OF X = LOW WORD OF MULT.
5   MOV    X+2,DX      ; HIGH WORD OF X = 0
```

The compilers generated this machine code for the assignment statement, X := W* 10000. (The line numbers and comments are the author's.) The compiler falsely zeroed out the high-order word by performing an exclusive OR on DX.

When the 8088 executes a multiply instruction, such as the one on line 2 in the generated code example, the results are returned in the DX and AX registers. DX contains the high-order word of the answer, and AX contains the low-order word. In this example, the compiler falsely zeroed out the high-order word by performing an exclusive OR on DX (line 3). Because of this compiler mistake, the high-order word of the variable *X* is incorrectly set to 0.

Listing 5 contains a short program, BUG4.PAS, to demonstrate this problem. With *w* equal to 9 and *i* equal to 9,

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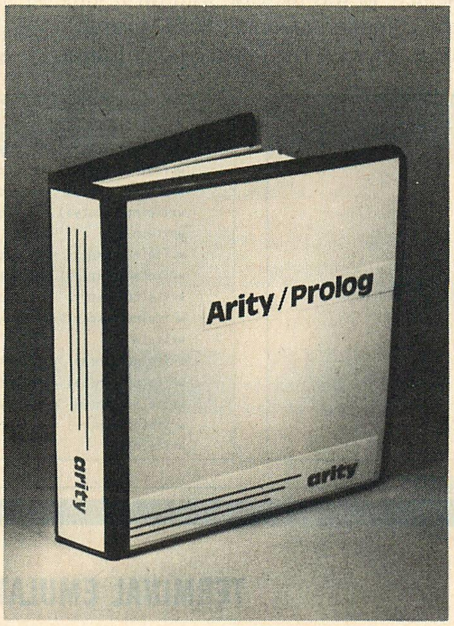

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when multiplied by 10,000, both answers should be 90,000. Although $i * 10{,}000$ gives the correct answer, $w * 10{,}000$ becomes 24,464.

Bug 5: Pascal programs work on PC and XT but fail on AT. When run on a PC/AT, my Pascal programs, which worked on the PC and PC/XT, consistently gave wrong floating-point answers. As a long shot, I tried linking my Microsoft Pascal 3.2 programs with the IBM 2.0 version of PASCAL.LIB. Suddenly, the programs seemed to work.

The IBM Pascal 2.0 compiler is a derivative of MS-Pascal 3.2. Before IBM released version 2.0, it must have tested the compiler on prototype ATs, discovered some compatibility problems, and then fixed them.

MS-Pascal uses an Intel-documented technique for automatically detecting the presence or absence of a math coprocessor. The technique works just fine on PCs or XTs for accurately detecting the 8087. Unfortunately, when that technique is used on the AT, an 80287 is always detected, whether or not it is actually present.

Based on the answer from the coprocessor-detection-test, Microsoft Pascal either generates floating-point instructions or emulates them. On the AT, MS-Pascal always thinks that an 80287 coprocessor is present to do floating-point operations. If no 80287 is installed, as was the case with my testing, the compiler generates 80287 instructions anyway. The floating-point instructions then end up executing on an empty chip socket, and, therefore, the answers that are returned are always 0.

Microsoft has fixed this bug in the upcoming 3.3 release of the compiler. In the meantime, software developers and end-users alike should be aware of this problem; the failure of a program to operate properly on an AT may or may not be obvious and, of course, could be devastating to a data file.

PC Tech Journal soon will publish code that determines in which members of the PC family the program is executing and establishes the presence or absence of the coprocessor.

Ted Forgeron is vice-president of systems software engineering at Multisoft Corporation located in Beaverton, Oregon.

LISTING 1: BUG1.PAS

```
{ BUG1.PAS                                         }
{ This program demonstrates how MS-Pascal 3.13 gets }
{ confused by extra parentheses around REAL library }
{ functions.                                        }
{                                                   }

PROGRAM bug1(output) ;

  VAR
    x : real4 ;
    y : real8 ;

  BEGIN {bug1}
    x := 55.55 ;
    y := 55.55 ;
    writeln('BUG1 RESULTS') ;
    writeln(' cos(x)   = ',cos(x)) ;
    writeln('(cos(x)) = ',(cos(x))) ;
    writeln(' cos(y)   = ',cos(y)) ;
    writeln('(cos(y)) = ',(cos(y))) ;
    writeln ;
    writeln(' exp(x)   = ',exp(x)) ;
    writeln('(exp(x)) = ',(exp(x))) ;
    writeln(' exp(y)   = ',exp(y)) ;
    writeln('(exp(y)) = ',(exp(y))) ;
    writeln ;
    writeln(' ln(x)   = ',ln(x)) ;
    writeln('(ln(x)) = ',(ln(x))) ;
    writeln(' ln(y)   = ',ln(y)) ;
    writeln('(ln(y)) = ',(ln(y))) ;
    writeln ;
```

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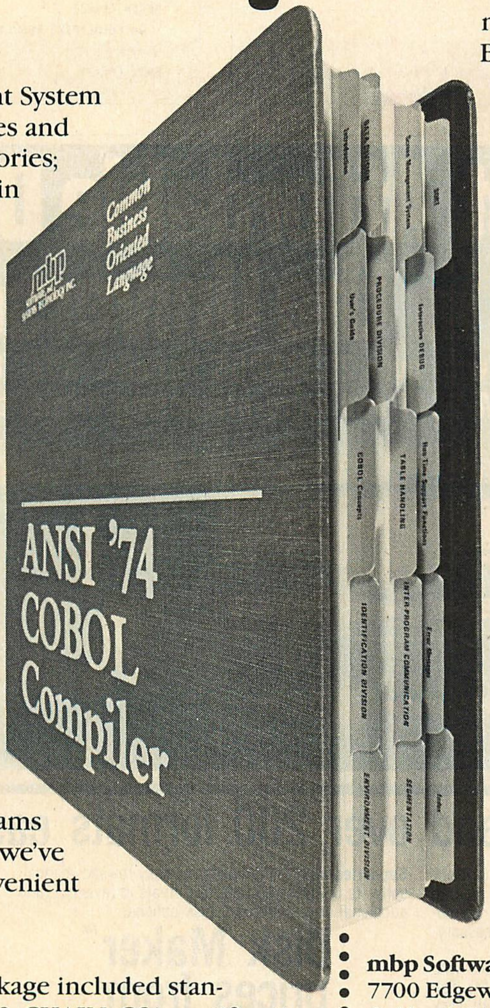

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```
    writeln(' sin(x)  = ',sin(x)) ;
    writeln('(sin(x)) = ',(sin(x))) ;
    writeln(' sin(y)  = ',sin(y)) ;
    writeln('(sin(y)) = ',(sin(y))) ;
    writeln ;
    writeln(' sqrt(x)  = ',sqrt(x)) ;
    writeln('(sqrt(x)) = ',(sqrt(x))) ;
    writeln(' sqrt(y)  = ',sqrt(y)) ;
    writeln('(sqrt(y)) = ',(sqrt(y))) ;
  END. {bug1}
```

LISTING 2: BUG2.PAS

```
{ BUG2.PAS                                           }
{ This program demonstrates how MS-Pascal 3.20       }
{ fumbles with nested REAL assignments.              }
{                                                    }

PROGRAM bug2(output) ;

  PROCEDURE outer ;

    VAR
      x,y : real ;

    PROCEDURE inner ;

      BEGIN {inner}
        x := y ;
        writeln('x and y should both equal 77.77') ;
        writeln('x = ',x) ;
        writeln('y = ',y) ;
      END ; {inner}

    BEGIN {outer}
      x := 55.55 ;
      y := 77.77 ;
      inner ;
    END ; {outer}

  BEGIN {bug2}
    writeln('BUG2 RESULTS') ;
    outer ;
  END. {bug2}
```

LISTING 3: FIX2.PAS

```
{ FIX2.PAS                                           }
{ This program demonstrates how to work around the   }
{ problems that MS-Pascal has with nested REAL       }
{ assignments.                                       }
{                                                    }

PROGRAM fix2(output) ;

  VAR
    y : real ;

  PROCEDURE outer ;

    VAR
      x : real ;

    PROCEDURE inner ;

      BEGIN {inner}
        x := y ;
        writeln('x and y should both equal 77.77') ;
        writeln('x = ',x) ;
        writeln('y = ',y) ;
      END ; {inner}

    BEGIN {outer}
      x := 55.55 ;
      y := 77.77 ;
      inner ;
    END ; {outer}

  BEGIN {fix2}
    writeln('FIX2 RESULTS') ;
    outer ;
  END. {fix2}
```

LISTING 4: BUG3.PAS

```
{ BUG3.PAS                                         }
{ This program demonstrates how MS-Pascal 3.13, 3.20 }
{ and IBM Pascal 2.0 goof up on REAL VAR parameters. }
{                                                  }

PROGRAM bug3(output) ;

  VAR
    x : real8 ;

  PROCEDURE pass_var(VAR a:real8) ;

    BEGIN {pass_var}
      writeln('cos(x)  = ',cos(a)) ;
      writeln('exp(x)  = ',exp(a)) ;
      writeln('ln(x)   = ',ln(a)) ;
      writeln('sin(x)  = ',sin(a)) ;
      writeln('sqrt(x) = ',sqrt(a)) ;
    END ; {pass_var}

  PROCEDURE pass_vars(VARS b:real8) ;

    BEGIN {pass_vars}
      writeln('cos(x)  = ',cos(b)) ;
      writeln('exp(x)  = ',exp(b)) ;
      writeln('ln(x)   = ',ln(b)) ;
      writeln('sin(x)  = ',sin(b)) ;
      writeln('sqrt(x) = ',sqrt(b)) ;
    END ; {pass_vars}

  BEGIN {bug3}
    x := 33.33 ;
    writeln('BUG3 RESULTS') ;
    writeln ;
    writeln('Here is what happens
            when x is not passed as a parameter:') ;
    writeln('cos(x)  = ',cos(x)) ;
    writeln('exp(x)  = ',exp(x)) ;
    writeln('ln(x)   = ',ln(x)) ;
    writeln('sin(x)  = ',sin(x)) ;
    writeln('sqrt(x) = ',sqrt(x)) ;
    writeln ;
    writeln('Here is what happens
            when x is passed as a VAR parameter:') ;
    pass_var(x) ;
    writeln ;
    writeln('Here is what happens
            when x is passed as a VARS parameter:') ;
    pass_vars(x) ;
  END. {bug3}
```

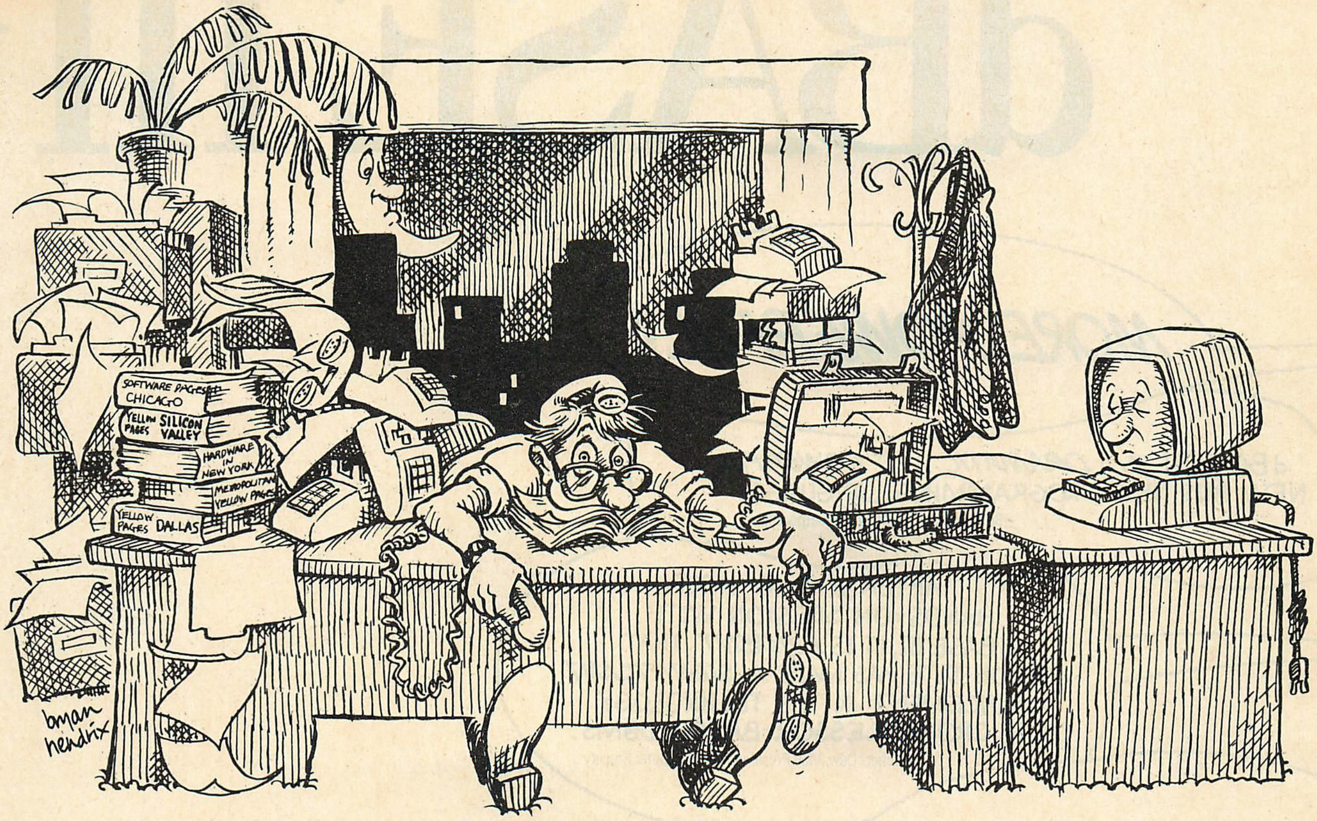
LISTING 5: BUG4.PAS

```
{ BUG4.PAS                                         }
{ This program demonstrates how MS-Pascal 3.20     }
{ messes up when a WORD is multiplied by a         }
{ constant and is then assigned to a double-word   }
{ integer.                                         }
{                                                  }

PROGRAM bug4(output) ;

  VAR
    x : integer4 ;
    i : integer ;
    w : word ;

  BEGIN {bug4}
    w := 9 ;
    i := 9 ;
    writeln('BUG4 RESULTS') ;
    writeln('w = ',w) ;
    writeln('i = ',i) ;
    writeln('Both answers should be 90000') ;
    x := w * 10000 ;
    writeln('w * 10000 = ',x) ;
    x := i * 10000 ;
    writeln('i * 10000 = ',x) ;
  END. {bug4}
```



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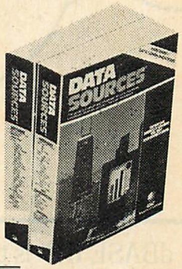

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The Powers that Be

Many Pascals offer no facilities to handle powers of numbers; here are two functions that do.

How would a user handle powers of numbers in Pascal? In FORTRAN or BASIC he would write X**Y or X^Y to accomplish a surprisingly complicated task, but many Pascals do not offer such a facility beyond SQR(X), which squares X, or SQRT(X), which finds the square root of X. (Noteworthy exceptions are Microsoft and IBM Pascals, which do include such a function).

Two functions are provided here that calculate the value of X, where X is real and Y may be either real or integer. Listing 1, PWRR(X,Y), is a function that provides answers for the real case and listing 2, PWRI (X,N), is the corresponding function for integer exponents. No function is provided specifically for integers to an integer power, although one certainly could be written. In that case, it would be necessary to decide what is meant by, for example, 2^{-2}. Either of the functions provided here would yield 0.25, but if integer arithmetic is desired, the result should be 0. Obviously, PWRI can be used with the understanding that all results less than 1 in absolute value are taken to be 0. The reader is challenged to write a suitable algorithm for this case using the ideas presented here.

If Y is type real, then the formula PWRR := EXP(Y*LN(X)) must be used; this formula will fail, however, under certain conditions. If $X < 0$, LN(X) is a complex number, and Pascal does not support type complex. LN(0) is undefined, so the cases of 0^Y must be handled separately. First of all, 0^0 is undefined, so that one is ruled out. If $Y > 0$, then $0^Y = 0$ for all such Y. Last, but not least, is the case where $X = 0$, $Y < 0$. Because X^{-Y} X^{-Y} means $1/(X^Y)$, this case leads to division by zero, a circumstance that the computer (not to mention mathematicians) resents.

The function PWRR(X,Y) is shown in listing 1. Note that the tests of the values of X and Y in the function correspond to the remarks above. The function was tested in Turbo Pascal.

If Y is type integer the computation can be speeded up. The computations of LN and EXP are relatively slow because they involve the calculation of truncated infinite series in which the coefficients have been slightly fudged to compensate for the truncation.

Instead, an ancient Arabian algorithm, closely related to "Russian peasant multiplication," and known to the western world only since the Renaissance, is invoked. In this algorithm, the binary representation of the exponent is scanned from right to left to produce a pattern of squaring and multiplication operations that provides a near-optimum computation time (listing 2). For example, X^5 is computed as $(X*X)^2*X$ with only three multiplications, but the computation $X^5 = X*X*X*X*X$ requires four operations. The algorithm does not save a lot of time for small exponents, say for those that are less than ten, but it does speed execution for computations with large exponents.

Again, there are restrictions on X and N for PWRI(X,N). In this case, $X < 0$ with $N > 0$ is permitted, but 0^0 is still undefined. $X = 0$ with $N < 0$ implies division by zero and must be excluded, as before, and $X = 0$ with $N > 0$ yields 0. If $X > 0$ and $N < 0$, the bit-search algorithm must be applied to ABS(N) and a reciprocation must be done at the end. PWRI(X,N) is also written in Turbo Pascal, as shown in listing 2. In neither function is there any protection against overflow. An attempt to calculate 1000^{1000} will yield whatever runtime error messages a given Pascal system provides. Otherwise, the functions are as foolproof as possible. Listings 3 and 4 are driver programs that test the functions PWRR(X,Y) and PWRI(X,N).

Paul F. Hultquist is a professor of electrical engineering and computer science at the University of Colorado at Denver. He has a Ph.D. in physics and has been teaching in the computer field for almost 30 years.

LISTING 1: PWRR.PAS

```
FUNCTION PWRR(X,Y: REAL): REAL;

{PWRR finds X (real) to the power Y (real) using logarithms and
exponentials.  If Y is an integer PWRI is faster.  The function
eliminates the undefined cases, and the case where the result is
complex.}

BEGIN

  IF X>0 THEN PWRR := EXP(Y*LN(X))

  ELSE IF X<0 THEN
    BEGIN
      WRITELN('X < 0. Halt.');
      HALT
    END

  ELSE IF (X=0) AND (Y=0) THEN
    BEGIN
      WRITELN('0 to the 0 power. Halt.');
      HALT
    END

  ELSE IF (X=0) AND (Y<0) THEN
    BEGIN
      WRITELN('0 to a negative power. Halt.');
      HALT
    END

  ELSE PWRR := 0.0

END;
```

LISTING 2: PWRI.PAS

```
FUNCTION RLSCAN(X: REAL; N: INTEGER): REAL;

{This function scans the positive exponent N from right to left
to determine a sequence of multiplications and squarings that
produce X (real) to the power N (integer) in a near-minimum
number of multiplications.  It is used as a function in the
function PWRI, listed below.  The algorithm is Algorithm A, page
442, Vol. 2, 2nd Ed. of Knuth: "The Art of Computer Programming:
Seminumerical Algorithms", Addison-Wesley, 1981.}

VAR   Y,Z: REAL;
        O: BOOLEAN;
     BIGN: INTEGER;

BEGIN

  BIGN := N; Y := 1.0; Z := X;
  WHILE BIGN > 0 DO
    BEGIN
      O := ODD(BIGN);
      BIGN := BIGN DIV 2;
      IF O THEN
        BEGIN
          Y := Y*Z;
          RLSCAN := Y
        END;
      Z := Z*Z
    END;

END;


FUNCTION PWRI(X: REAL; N: INTEGER): REAL;

{PWRI performs the tests necessary to eliminate the non-
computable cases of finding X (real) to the power N (integer).
It calls upon function RLSCAN to do the actual computation
after it has, for example, replaced a negative exponent by
a positive one (it does a reciprocation after return from
RLSCAN in that case).}

BEGIN

  IF (N>0) THEN PWRI := RLSCAN(X,N)
  ELSE IF (X<>0.0) AND (N<0) THEN
    BEGIN
      N := -N;
      PWRI := 1.0/RLSCAN(X,N)
    END
  ELSE IF (N=0) AND (X<>0) THEN PWRI := 1.0
  ELSE IF (N=0) AND (X=0) THEN
    BEGIN
      WRITELN('0 to the 0 power. Halt.');
      HALT
    END
  ELSE IF (N<0) AND (X=0) THEN
    BEGIN
      WRITELN('Division by zero. Halt.');
      HALT
    END

END;
```

LISTING 3: PWRRTST.PAS

```
PROGRAM PWRTST;

{This is a driver program to test out function PWRR(X,Y), where
X,Y, and PWRR are type REAL.  See the header on the function (and
the article) for more information.}


VAR X,Y,Z: REAL;

{$I PWRR.PAS}

BEGIN

  WRITELN('Enter X and Y');
  READLN(X,Y);
  Z := PWRR(X,Y);
  WRITELN(Z)

END.
```

LISTING 4: PWRITST.PAS

```
PROGRAM PWRITST;

{This is a driver program for testing the function PWRI which
calculates X (real) to the power N (integer).  The method of
calculation is explained in the article and in the header of
function PWRI.}

VAR  Z,X: REAL;
       N: INTEGER;

{$I PWRI.PAS}

BEGIN

  WRITELN('Input X,N');
  READLN(X,N);
  Z := PWRI(X,N);
  WRITELN;
  WRITELN(Z);

END.
```

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Block Commands

Copy/Move/Delete
Read/Write
Lower Case/Upper Case
Fill/Justify
Print

File Commands

Directory (with wild cards)
Show File/Help File
Input/Output File
Delete File/Save File

Other Commands

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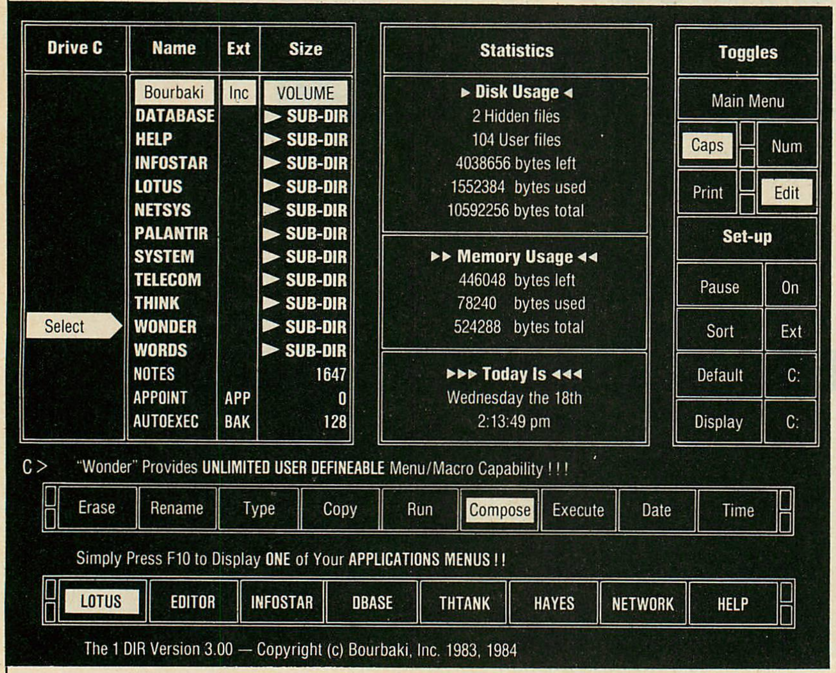

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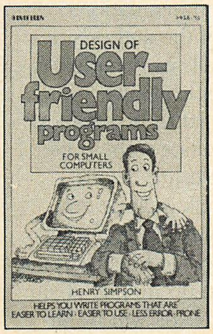
User-friendly or Foe?

In attempting to be user-friendly, this book discusses the range of end-user issues, but sometimes too lightly.

Design of User-Friendly Programs for Small Computers
Henry Simpson (McGraw-Hill Book Company, New York, NY, 1985) 230 pages; paper, $18.95



Every programmer wants to design software that is user-friendly. But that desire and a finished product that fits the bill are often separated by a chasm—the ability to accomplish the feat in the face of little or no information on just what makes a program easy to use.

Oh sure, there are a lot of books on human factors that can help. (Human factors are characteristics of people that influence their ability to perform.) But these books are usually scholarly in tone (read "hard to understand"), and their conclusions seldom apply directly to program design.

With *Design of User-Friendly Programs for Small Computers*, Henry Simpson has taken the question of human factors to the designers of computer programs. And although this book does not discuss many of its subjects very fully, it does offer useful tips on a wide range of design issues.

The first chapter introduces some concepts important in the design of easy-to-use programs. It stresses the programmer's attitude as one of the most significant factors. By keeping the user constantly in mind, the programmer is more likely to include many human-engineered features instead of, as often is the case, adding them as an afterthought.

Chapter 2 looks at the human operator and describes the inherent characteristics that should influence the design of programs. It shows how the effective use of sound (such as beeping when an error occurs) and visual properties (such as color, brightness, and flashing characters) can improve an individual's ability to use a program. It discusses memory and the general inability of people to remember too much for too long.

This chapter also divides users into several classifications and points out that different types of users have different types of needs. For example, first-time users might require menus and help information to guide them through the program. But once those users become familiar with program operation, they probably will wish for a faster way. By defining the program's audience before writing it, and designing the program to adapt to the different kinds of persons in that audience, a programmer may be able to improve the usability of the software he creates.

Chapter 3 offers 12 principles for programmers to consider when designing programs. Most are obvious, such as keeping the program simple, being consistent, and giving adequate feedback. Nevertheless, many existing programs do not adhere to all of the principles outlined here and might have benefited from having done so. (How many times has a user wondered whether a program he is using has crashed or is simply taking its sweet time? A helpful "Please wait" message could relieve a little of that tension.)

Chapter 4 discusses the program development process. Here the author notes that most programs are designed either top-down (defining general modules first, and breaking each into more and more detail) or bottom-up (designing specific functions and combining them to provide more general operations). Both of these design methods are inside-out—that is, they concentrate on the inside of the program first and the operator interface second. This chapter outlines steps that the programmer can take to make program development an outside-in process.

To some extent, chapter 5 is about design considerations based on different kinds of hardware, such as monitors, printers, and input devices. Unfortunately, this chapter is concerned not so much about designing software, but more about choosing the proper hardware for a given situation. When the chapter does touch upon design issues (such as when light pens, mice, and trackballs are especially useful), it skims over them very briefly.

Chapter 6 describes program output. It gives advice on screen layout, the use of language, tabular versus graphic presentation, color and brightness coding, and more. It offers good advice on designing useful screens and reports.

Similarly sound advice is offered in chapter 7, which deals with data input. The author stresses that programs should be adjustable so that the operator can control when and where data are entered. And the chapter warns against giving programs insulting, patronizing, or even human personalities. Also discussed are methods that should be used in programs to request and validate information from users.

Program utilities, such as system set-up, file creation, and database editing, are the subjects of chapter 8. The need for such utilities is explained, and, in addition, some relative guidelines and flowcharts are included.

Chapter 9 covers program control: the way the operator interacts with a program. The author discusses computer-initiated dialogue (such as asking specific questions or displaying menus) and operator-initiated dialogue (the blinking cursor at which the operator can enter any command).

The last two chapters are about documentation and testing. Chapter 10 provides suggestions for writing two different kinds of documentation: system (or internal) and end-user. Chapter

11 describes the different types of testing that should take place before a program is considered finished.

Although this book contains many interesting tidbits, none of its information is very new or startling. Anyone who has ever worked on a major piece of consumer software will already know everything this book has to offer. It also has an annoying tendency to offer statements without providing enough information to back them up. For example, chapter 5 recommends against using color unless it is really needed. This is followed by a list of instances in which color could improve the usability of a program. But the author never gets around to explaining why one should not use color just to brighten up an otherwise dreary graphics screen.

This tendency to leave out the reasons behind the recommendations could be the result of the author's desire to avoid the pitfalls of complex, human factors textbooks. However, by bending over backward to be simple, the book misses a chance to help its readers by providing more details.

Nor does the book include any programming examples. Programmers who are expecting detailed instructions on how to create pop-up menus of situation-specific help screens will be disappointed. This lack of programming examples tends to make some of the chapters (notably the chapter on utilities) mere hand-waving exercises.

A final complaint: the book tends to wander from the main point occasionally. Although the chapters on hardware, documentation, and testing provide some useful information, not much of it applies to designing programs. Still, for programmers who are relatively new at designing end-user software, this book can be worthwhile. It offers many design tips that might otherwise take months or years to discover. And the chapters on input and output may help even a veteran programmer to design better screens.

—STEVEN ARMBRUST

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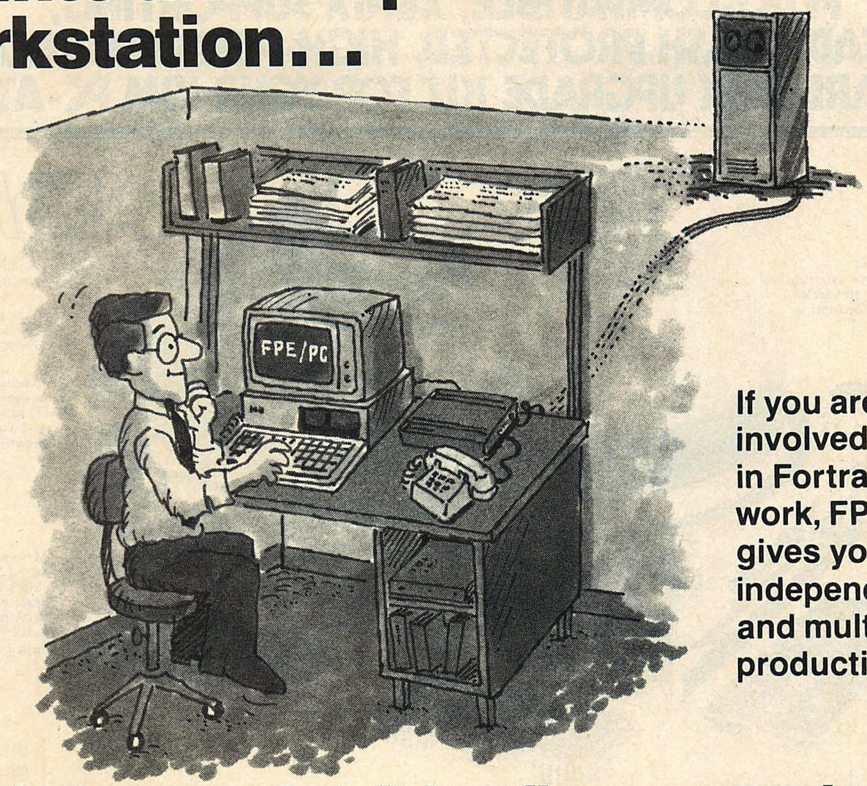

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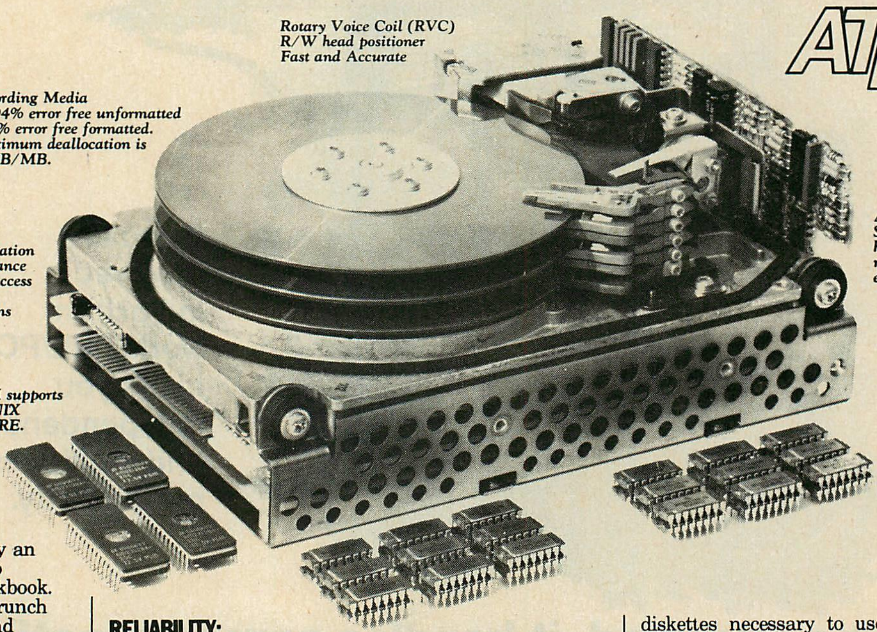

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Winchester heads read and write while "flying" a few microns above the data surface. If the heads contact the recording media, you risk a head crash, and significant or total data loss.

So, even a fast drive without data protection is virtually worthless. Frankly, we'd rather sleep at night.

BEWARE OF USER-DEPENDENT PROTECTION SCHEMES.

Some drives have a safe landing zone for the heads, but you need to call a separate program to send 'em there. If you don't call that program, and most folks won't, the heads in these drives ALWAYS land on data when powered down.

The slightest bump or vibration can move the heads, wiping out those data tracks. And the R/W heads can become contaminated, thus increasing the error rate, slowing down average access until the whole drive fails.

Consequently, those drives offer a very high risk of head crashes, a false sense of security, and little else.

What's your data worth? $200? $400? Specify AUTOMATIC data protection. ATplus has it. And it doesn't cost, it pays.

PEACE OF MIND.

Specify AUTOMATIC park and lock of the heads on power down.

This system provides unparalleled head crash protection, by sensing power loss to the drive, and retracting the heads to a dedicated landing zone before they can land on your data.

Since this is 100% automatic, user-dependent risk is eliminated.

OUR DRIVES HAVE ALL BEEN TO BOOT CAMP.

Avoid drives that CLAIM PC-AT compatibility but can't BOOT the AT. By the time you juggle the diskettes necessary to use one of those drives, the phrase "user-hostile" will have deep personal significance.

We believe that computers ought to serve people, not the other way around.

BEWARE OF THE BARGAIN BAND-SCHLEPPER.

Avoid drives with inexpensive Band-Stepper positioner technology. These were pretty good way back in 1980, considering that's all anyone had. But by today's standards, they're inaccurate and very mechanical.

They waste time looking for the right track to read or write. And they're worth no where near the price you'll pay for 'em –in more ways than one.

THE HIGH TECH SOLUTION.

Specify state-of-the-art ROTARY VOICE COIL (RVC) head positioner and CLOSED LOOP SERVO technologies.

This system uses a DEDICATED SERVO SURFACE (DSS) for continuous head location information.

The RVC and DSS use a large scale microprocessor to translate new track-seek commands into current that is applied directly to the RVC.

This moves and holds the R/W heads at the exact track intended.

Speed is dramatically increased since head movement is created electronically, with minimal mechanical interfacing.

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CIRCLE NO. 166 ON READER SERVICE CARD

R&D Tax Incentives

The tax code offers incentives to companies wanting to step up their research and development efforts.

How do you react when you hear the phrase, "I'm from the government, and I'm here to help you?"

Right. Okay, loosen your grip on your wallet—this is only a rhetorical question. The government really does want to help companies willing to increase their research and development efforts and, if these companies act quickly, they may be able to take advantage of provisions of the tax code that will save money, let them show their customers how to reduce the after-tax cost of the company's services, and show investors how the government can help underwrite part of the risk of their investment. The magic provisions to which I refer are Internal Revenue Code Sections 174 and 30.

Section 174 of the code provides that "research or experimental expenditures" incurred in connection with a trade or business are deductible and need not be amortized over the useful life of the resulting technology.

In 1981, Congress decided that not enough money was being spent by the private sector on research and development. To spur such activities, Congress included in the Economic Recovery Tax Act of 1981, a provision creating a Research and Development Tax Credit (now known as Internal Revenue Code Section 30). The only problem with this tax credit is that time is running out; Section 30 is scheduled to expire December 31, 1985.

Under Section 30, a taxpayer is entitled to a credit (a dollar for dollar reduction of tax) equal to 25 percent of the amount by which *qualified research expenses* for the year exceed *base period research expenses.* A whole volume of information is concealed in that simple statement, and the purpose of this article is only to alert the reader to the possibility that the federal government may in fact be in a position to help. The extent of that help can be determined only on an individual basis, which is why there are accountants and spreadsheet programs.

To determine whether a company can benefit, it is necessary to compute base period research expenses. For 1985, they are the greater of: (1) the average of "qualified research expenses" for the preceeding three tax years; or (2) one-half of the qualified research expenses for the current year.

Qualified research expenses include costs that are incurred in a trade or business, either in-house or by contract with another party, for developing or improving an experimental or pilot product, invention, or similar product. The expenses must be generated by a project that is of an experimental nature—minor improvements to an existing product about which there is no doubt of feasibility do not qualify. The Internal Revenue Service defines *research or experimental expenditures* in the following way:

> "The term . . . means expenditures incurred in connection with the taxpayer's trade or business which represent research and development costs in the experimental or laboratory sense. The term includes generally all such costs incident to the development of an experimental or pilot model, a plant process, a product, a formula, an invention, or similar property, and the improvement of already existing property of the type mentioned. The term does not include expenditures such as those for the ordinary testing or inspection of materials or products for quality control or those for efficiency surveys, management studies, consumer surveys, advertising, or promotions. However, the term includes the costs of obtaining a patent, such as attorneys' fees expended in making and perfecting a patent application. On the other hand, the term does not include the costs of acquiring another's patent, model, production or process. . ."

Separate rules apply to the calculation of qualifying expenses, depending on whether the expenses are incurred in-house or are paid to another company (referred to in the Code as *contract research expenses*). In-house qualified expenses include the costs of wages, supplies, and equipment rentals necessary for the qualified project; contract research expenses qualify to the extent of 65 percent of amounts paid to a third party for qualified research.

Expenses to develop a product that is intended to be transferred in exchange for royalties cannot be counted as qualified research expenses for the developer; however they could qualify for the purchaser.

Having computed base year qualified expenses, the process is repeated for the current year (except that 65 percent of contract research expenses is included). Then subtract the base year qualified expenses, take 25 percent of the difference, and that is the amount of tax savings attributable to R&D (subject, of course, to the normal limitations on tax preference items).

BENEFITS FOR CONSULTANTS

If a company is engaged in its own qualified research and development, the benefits are obvious. However, the R&D tax provisions can also provide benefits to other companies in less obvious ways. Two examples are the private consulting business, and the financial backers of R&D ventures.

A private consultant (or other contractor) can benefit by structuring his services so that his client can get the benefit of the contract expenditures R&D credit. For example, if the client had no previous qualifying expenses, then it is entitled to a benefit of (25% * 65%)−(0.5 * 25% * 65%), or 8.125 percent of the amount that is paid to its consultant for qualifying research and development. In other words, the government will give the consultant's client an 8-percent rebate—not a bad sales tool to have at hand.

If the type of research requires substantial overhead or capital expenses, a consultant may be able to structure the transaction so that a client will save money by contracting for the work rather than doing it in-house. Remember that in-house expenditures are limited to wages, supplies, and equipment rental; they do not include overhead or the purchase price of equipment. On the other hand, the credit for contract services is based on the contract price (regardless of the components of that price, provided that the contract is for qualified expenses), but qualifies only to the extent of 65 percent of the price. Therefore, in the simple case in which the client can take full advantage of any available tax credits, and in which the client has no base year qualifying expenses, it will be cheaper to contract for the work in situations where:

In-house Cost – (12.5% * (*wages* + *supplies* + *equipment rent*)> *Contract Price* * 91.875%

The contractor might even convince the client that a "best-efforts" contract would be advantageous (where the contractor is obligated to use his best efforts, but is not obligated to achieve any particular result), since that would strengthen the position that the project was indeed development "in the experimental or laboratory sense."

HIGH-TECH INCENTIVE

The tax code can also be used to provide an incentive to investors in high-tech ventures. The structure of such financing is complicated, but the basic pattern is quite simple. If investors were to invest directly in a high-tech corporation, they would receive immediate tax benefit. The result would be different, however, if the technical specialists form Company A, the investors form Company B (usually in a limited partnership), and then Company B contracts with Company A to develop the new technology. Internal Revenue Code Section 174 makes the research expenditures currently deductible and, under the proper structure, this deduction can benefit the investors individually.

Under some circumstances, the tax credit also may be of benefit to the investors, although this will depend in part on whether the research is deemed to be incurred "in carrying on" a trade or business (a phrase that has a technical meaning in tax law). Whether the tax credit is available or not, the deduction provides investors with an immediate tax benefit that reduces the net risk of their investment. Typically, the technical specialists reserve an option to acquire a license to use any resulting technology for a royalty that will give the investors a satisfactory return on their investment. The technical specialists may take an additional option to acquire the technology itself after the holding period necessary to qualify for long-term capital gains treatment passes.

With proper planning everyone benefits: the technical specialists can improve their competitive position or reduce the cost of (and increase the likelihood of obtaining) financing; consumers of high-tech services can lower their net costs; investors can receive tax benefits that reduce their risk and increase their profit potential; and Congress can achieve the increased private sector research efforts that it deemed necessary a few years ago.

Max Stul Oppenheimer, PC, is a partner in the law firm of Venable, Baetjer & Howard, located in Baltimore.

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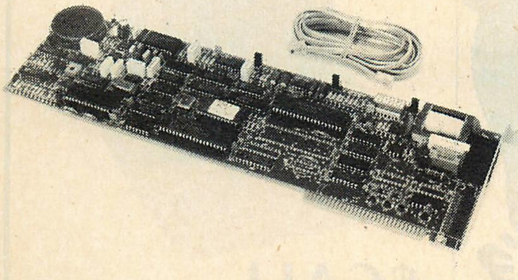

QIC-03 300/1200 baud Modem

This fully Hayes compatible modem has built-in speakers with auto-dial, auto-answer capabilities. With LSI "modem-on-a-chip" design, it gives exceptional reliability and data accuracy. Communication software is included.

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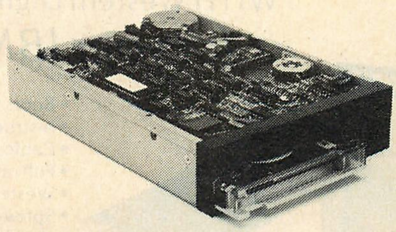

QIC-02 ST 20-60MB Internal Streaming Tape Back-up Unit

This internal high performance unit comes complete with controller, cable, tape drive and mounting rail for your AT. You can back up 20MB hard disk in less than 10 minutes. File by file or image back-up is provided.

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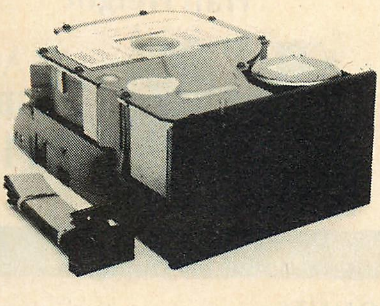

20-40MB Hard Disk Drives

Our 20-40MB drives have 40 MS seek time. It is fully compatible with your AT and comes with mounting rail and cables.

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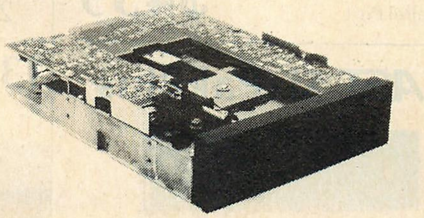

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Just plug these 18 RAM chips into your 256K AT system board to make it 512K.

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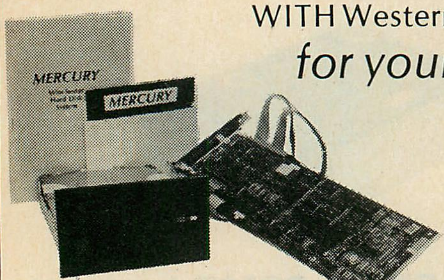

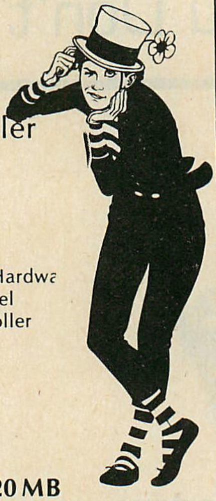

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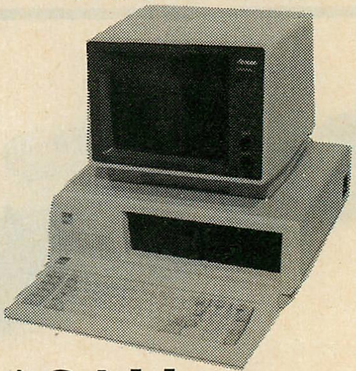

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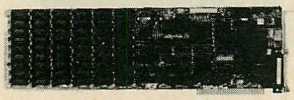
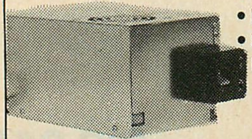


w/384K **$329**

130 Watt Power Supply



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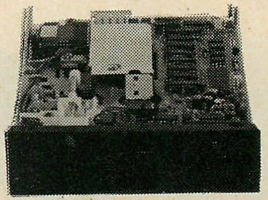

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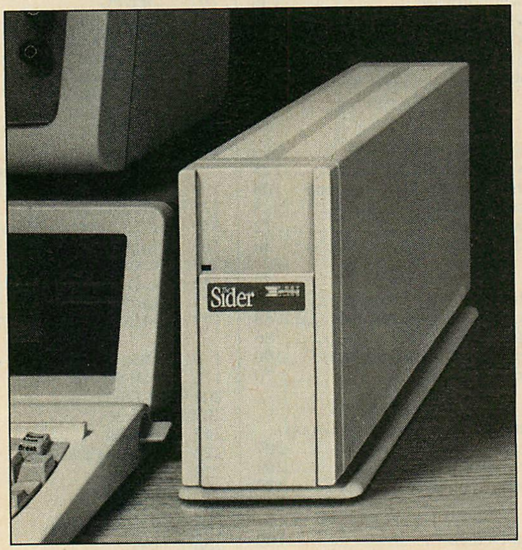
What every IBM PC user should ask before buying the "Sider" 10 MB hard disk:



"Only $795?"

When a company offers a superior quality 10 megabyte Winchester hard disk for only $795, it's bound to raise a few eyebrows…and a lot of questions. The fact is, you're probably already wondering "Can I really get a 10 megabyte hard disk that's *reliable* for only $795?" The answer is: ABSOLUTELY…when you choose the Sider from First Class Peripherals.

What's so great about the Sider?

For starters, the Sider lets you boot your ***IBM PC**** or ***PC/XT*** directly off the hard disk—unlike some other Winchester subsystems. Rebooting is also trouble-free. And the disk is partitionable, giving you a convenient way to organize your data, as well as access the information you store.

What's more, a small "footprint" lets you incorporate the compact Sider into your existing computer set-up with ease.

In addition, with the Sider, you not only pay far less for the subsystem, you also save money on installation. Because, unlike other 10 MB systems that require the purchase of expensive "extras," the Sider is *plug and play*. Everything you need is provided, including cables, host adaptor, installation software and manual.

What makes it so reliable?

To start, the Sider is manufactured, and sold exclusively, by First Class Peripherals, an innovative computer company which is backed by Xebec. The computer industry's leading manufacturer of disk controllers, Xebec has over a decade of experience serving customers like IBM, Toshiba, Texas Instruments and Hewlett Packard. It's this kind of expertise that helps assure the Sider's performance.

Special design features further enhance reliability. The Sider's controller is the field-proven, industry standard Xebec S1410A. And Xebec's 3200 drive tester, the toughest in the industry, ensures error-free media to keep the Sider operating reliably, longer. A self-contained power supply also adds to dependability by eliminating the risk of heat build-up that could cut PC component life. One more assurance of the $795 Sider's quality: it's UL Approved and FCC Class B rated.

*Must contain hard disk ROM.

But why is it only $795?

You pay less for the Sider than for other 10 MB hard disks simply because you're paying for the superior quality components inside the unit, not for a lot of retail overhead costs. Since First Class Peripherals sells direct, you avoid dealer and distribution expenses, and pay only for the product.

What about a guarantee?

Like many experienced PC users, you may be reluctant to buy a hard disk priced at only $795 without first seeing for yourself how it performs. That's why First Class Peripherals offers you a reassuring, money-back guarantee that eliminates any risk on your part. Simply order the Sider and use it for 15 days. Then, if you're not entirely satisfied, return it and receive a full refund—no questions asked.

The Sider also comes with a full one-year limited warranty. Plus, there's a convenient, toll-free hotline you can call anytime you have a technical or service question, or need help.

Don't delay. Order the Sider now.

To receive the Sider 10 megabyte Winchester hard disk subsystem for only $795, simply order using the coupon below. For faster service, order by phone and charge to your VISA, MasterCard or American Express. (You can also call us if you have any questions or technical concerns about the Sider. We'll see you get the help you need.) Call toll-free:

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Extension 106

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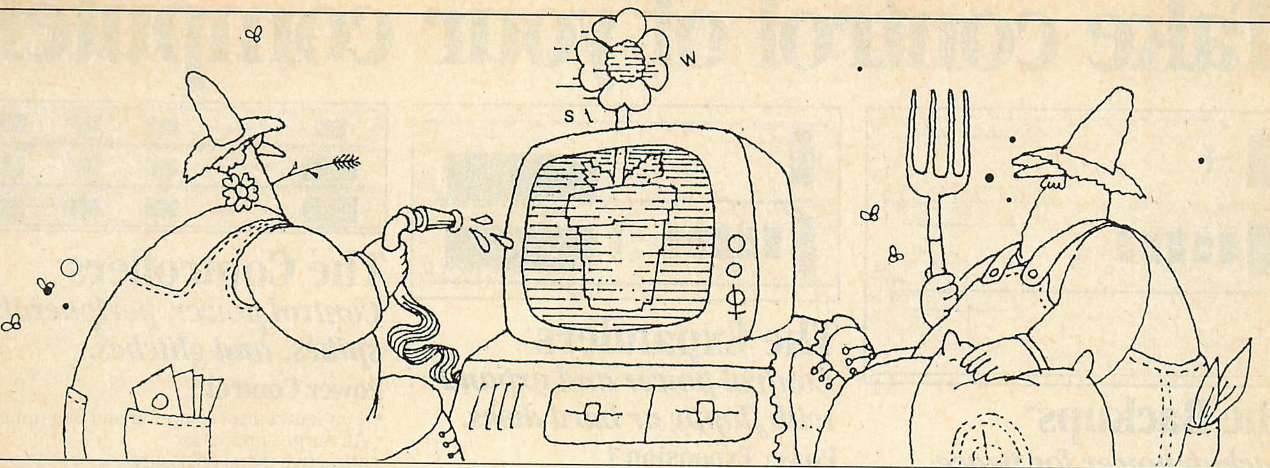

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MAY

May 2-3
End-User Computing: The Changing Role of the Systems Professional and the End User
Minneapolis, MN
Sponsor: ACM SIGBDP, ACM SIGCPR, University of Minnesota, and Indiana University
Contact: Robert P. Bostrom, Business 574, Indiana University, Bloomington, IN 47405; 812/335-8449

May 6-8
1985 ACM Symposium on Theory of Computing
Providence, RI
Contact: Robert Sedgewick, Dept. of Computer Science, Brown University, Box 1910, Providence, RI 02912; 401/863-1831

May 6-9
Comdex/Spring 85
Atlanta, GA
Contact: Amy Marks, The Interface Group; 617/449-6600

May 12-16
APL 85
Seattle, WA
Sponsor: ACM SIGAPL and Puget Sound Chapter of ACM
Contact: Robert Gailer, 12122 N.E. 150th Street, Kirkland, WA 98033; 206/575-7476

May 13-15
C-85: A Conference in C
San Francisco, CA
Sponsor: Joint Sponsorship
Contact: C-85 Planning Committee, c/o Lifeboat Associates, 1651 Third Avenue, New York, NY 10038; 800/467-4470

May 13-17
Fifth International Conference on Distributed Computing Systems
Denver, CO
Sponsor: IEEE-CS
Contact: Earl Swartzlander, TRW Defense Systems, One Space Park, Redondo Beach, CA 90278; 213/535-4177

May 14-16
International Ada Conference
Paris, France
Sponsor: ACM SIGADA
Contact: J. A. N. Lee, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061; 703/961-6931

May 20-22
Custom Integrated Circuits Conference '85
Portland, OR
Sponsor: IEEE
Contact: Dr. Wesley N. Grant, Sperry Computer Systems, Sperry Park, P. O. Box 43525 MS Y11B1, St. Paul, MN 55164-0525; 612/456-4130

May 21-22
Trends and Applications 85: Utilizing Computer Graphics
Silver Spring, MD
Contact: IEEE-CS, P. O. Box 639, Silver Spring, MD 20901; 301/589-8142

May 22-24
Computer Software and Human Development Conference
Toronto, Canada
Sponsor: SDA
Contact: Reuben Lando, Software Developers Association, 185 Bloor Street East, Suite 500, Toronto, Ontario, Canada; 416/922-1153

May 22-24
CAD 2001: The Countdown
Dallas, TX
Contact: CAD Seminars, Inc., 150 E. Riverside, Suite 400, Austin, TX 78704; 512/445-7342

May 27-31
Graphics Interface 85
Montreal, Canada
Contact: D. Thalmann, Departement d'Informatique et Rech. Oper., Universite de Montreal, C. P. 6128, Succ A., Montreal, P. Q., Canada H3C 3J7

May 28-30
IBM's Systems Network Architecture: A Structured Approach
Atlanta, GA
Sponsor: GIT
Contact: Elaine Hadden Nicholas, Dept. of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385; 404/894-2547

JUNE

June 9-13
Computer Vision & Pattern Recognition
San Francisco, CA
Contact: Computer Vision & Pattern Recognition, P. O. Box 639, Silver Spring, MD 20901; 301/589-8142

June 17-19
PC Expo
New York, NY
Sponsor: PC EXPO
Contact: PC EXPO, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632; 800/922-0324; in New Jersey, 201/569-8542

June 19-21
FTCS-15: 15th International Symposium on Fault-tolerant Computing
Ann Arbor, MI
Sponsor: IEEE-CS
Contact: John F. Meyer, Dept. of EECS, University of Michigan, Ann Arbor, MI 48109; 313/763-0037

June 20
Twenty-fourth Annual Technical Symposium
Washington, DC
Sponsor: ACM—Washington, DC chapter; U. S. Dept. of Commerce; NBS; and ICST
Contact: Richard I. Milstein, 131 N. Wakefield Street, Arlington, VA 22203

June 23-26
DAC 85, 22nd Design Automation Conference
Las Vegas, NV
Contact: Hillel Ofek, Silvar-Lisco, 1080 Marsh Road, Menlo Park, CA 94025; 415/324-0700

June 24-26
Videotex '85—Fifth Annual Conference and Exhibition
New York, NY
Contact: Online Conferences, Inc., 989 Avenue of the Americas, New York, NY 10018; 212/279-8898

June 25-28
ACM SIGPLAN 85 Symposium on Programming Languages and Programming Environments
Seattle, WA
Sponsor: ACM SIGPLAN and ACM SIGSOFT
Contact: Teri F. Payton, SDC, Box 517, Paoli, PA 19301; 215/648-7268

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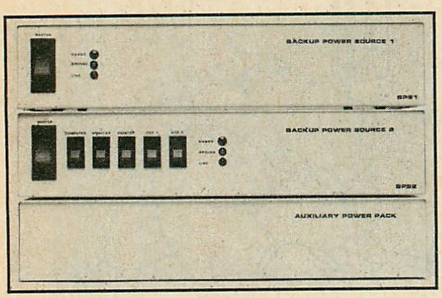

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- delivers up to 225 watts @ 120V.AC
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  (Within 6 milliseconds of peak voltage detection)
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- thermal output protection
- IEC power connector
- attractive metal enclosure
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All the features of Power Source 1 plus:

- 6 outlets controlled by front switches
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- 10 amp master switch circuit breaker
- cross suppression between all 6 outlets
- optional 2 hour auxiliary power pack

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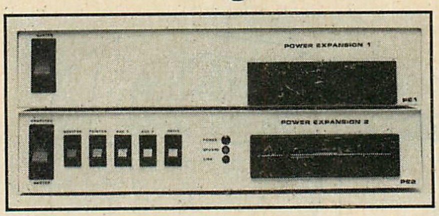

The Expanders™

Control power and expand with floppy or hard disks.

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- 1 stage noise filter
- AC surge suppression
- IEC power connector
- attractive metal enclosure
- 3¼″ high, 16″ wide, 11″ deep
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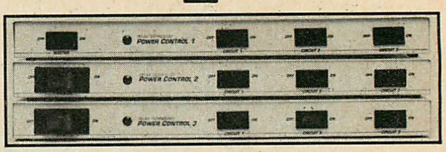

The Controllers™

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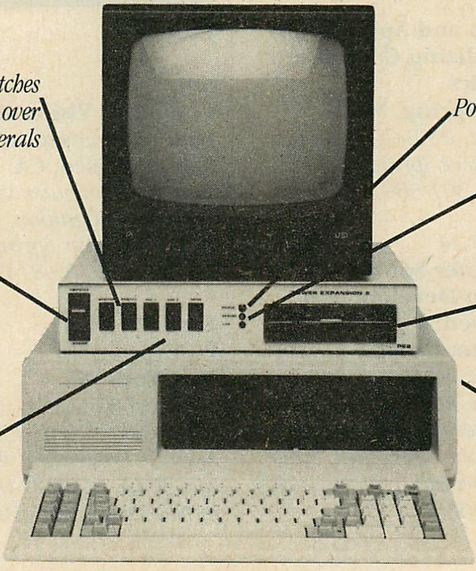
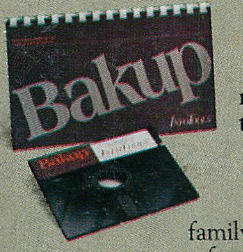


CIRCLE NO. 193 ON READER SERVICE CARD

TeamMate's Storage Solution: Two Minute Backup and Versatility



Two minutes to back up data?

It's true with TeamMate's family of storage subsystems featuring the remarkable Kodak™ 2.78 megabyte flexible drive and **free Bakup™** software.

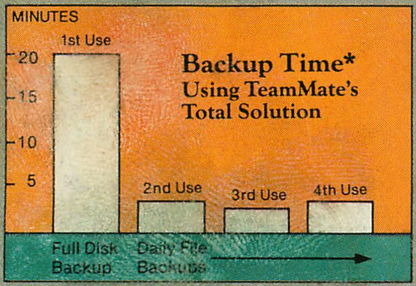
Frankly, most people know they need to protect their valuable data by backing up files regularly. They don't because it takes too long.

TeamMate has taken care of that.

All you do is back up your full hard disk once. 10 megabytes can be copied in about 20 minutes onto 3 or 4 Kodak high capacity diskettes.

Then TeamMate's easy-to-use Bakup software allows you to automatically back up your modified files in as little as 2 minutes!

New advances in backup are just part of the TeamMate/Kodak success story.



TeamMate's Winchester and Kodak 2.78MB flexible drive subsystems also add unprecedented flexibility and versatility to the IBM™ PC, AT, or compatible computers.

Kodak Drives... Unlimited Storage at a Low Cost

Install them internally or externally. Either way, TeamMate's family of Kodak 2.78MB flexible drives give you Winchester-like capacity, plus the convenient familiarity of a floppy. You get eight times the online storage capacity of a standard floppy... and unlimited expandability.

The Kodak 2.78MB drive guarantees media interchangeability from drive to drive, and it can also read standard IBM PC and AT diskettes—ideal for transporting your AT's data to standard PC's.

Need to achieve high capacity storage and rugged portability? Use our TeamMate 1103 (single Kodak drive) or the 1104, a Kodak drive and standard floppy combination—perfect for upgrading the XT. Or, use our external models featuring one or two Kodak drives to backup several PC's.

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TeamMate's combined Winchester and Kodak subsystems deliver the greatest versatility available today. Use the high speed Winchester, and back up your data with the Kodak flexible drive. Also use the Kodak for data security, diskette savings, or data archiving.

Installation takes only minutes... and there's no need for software drivers or patches.

The TeamMate 1123 installs internally and adds 20 megabytes of hard disk storage plus the Kodak flexible drive. External Winchester/Kodak combinations turn a minimum PC into a sophisticated supersystem.

Save... With TeamMate Winchester Subsystems

High performance and a variety of capacities. That's TeamMate's family of Winchester subsystems.

Add 10 or 20 megabytes of storage to your system either internally or externally. For really big jobs, look to TeamMate's 1132... 32 megabytes of formatted add-in storage.

Enhance a basic IBM PC AT configuration with 20 or 32 megabytes of reliable Winchester storage. TeamMate 1120 AT & 1132 AT attach directly to the AT's existing controller. Complete with drive, cable, mounting slides, and Bakup software, they're ready to go in just minutes.

Adding a TeamMate to your system is the cost-effective way to handle a variety of tasks.

Call TeamMate today for more information.

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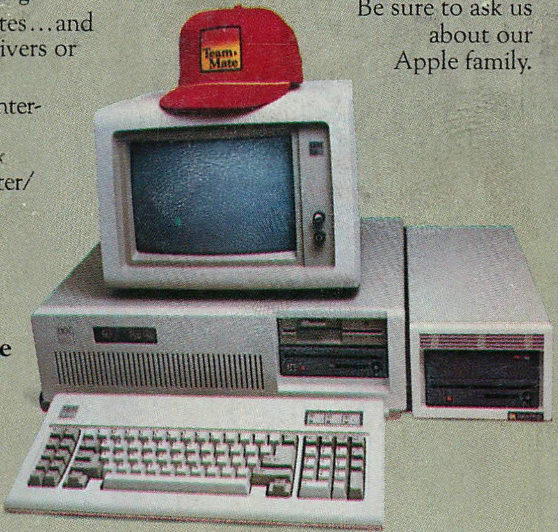

Only TeamMate's Kodak Drive Solves All Your System Needs	
✓ Hard Disk Backup	High speed full or selective file backup onto high capacity diskettes. 10MB hard disk needs only 4 Kodak diskettes.
✓ Primary Storage	2.78 megabytes of online random access storage
✓ Portability	Floppy ruggedness... ideal for portable computers
✓ Expandability	Unlimited storage capacity—just change diskettes
✓ Data Security	Removeability gives you ultimate data security without security software
✓ Interchangeability	Media interchangeability guaranteed from drive to drive
✓ Read Standard Diskettes	Reads standard diskettes so you can exchange data between IBM PCs and ATs
✓ Diskette Savings	One Kodak 2.78MB diskette replaces 8 standard IBM floppies.
✓ Convenience	Install in minutes using standard DOS software

Team•Mate

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